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PROCEEDINGS
of a
Meeting of an American Sub–Group
of the Council of
EDWARD A. BOUCHET–ICTP INSTITUTE

Edward a. Bouchet (1852–1918)
Ph.D. in Physics, 1876, Yale University

Co–Chairs of the Meeting
Charles Brown and F. K. A. Allotey

Organizer and
Editor of the Proceeding
Ronald E. Mickens

March 27–29, 1992
at
Clark Atlanta University
Atlanta, Georgia 30314 USA

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PREFACE

The Council of the Edward Bouchet–ICTP Institute was to meet in Atlanta, Georgia during October 1991. However, funding difficulties made it impossible for the non–American sited members to attend. A decision was then made to have a "working meeting" of only the American sited members of the council. The primary purpose would be to consider a number of critical issues relating to the smooth and effective functioning of the Institute and its various activities.

Ronald E. Mickens agreed to organize the meeting with F. K. A. Allotey and Charles Brown serving as Co–Chairs. At that time all of these persons were located in Atlanta at Clark Atlanta University.

The goal of the "working meeting" was to have a specific set of (preliminary) recommendations for resolution of the above indicated issues by the end of the meeting. This goal was to be implemented by arranging a number of sessions each of which considered a particular topic. Six sessions were organized with a Chair and Main Speaker. Chairs were asked to provide brief written summaries/comments on the discussions that took place in their session. Main Speakers were to make a formal presentation and provide a manuscript of their lecture. These notes/comments, manuscripts and related materials form the basis of this Proceeding volume.

The Meeting was purposely held small so that a friendly, but, serious working environment would be maintained. Fifteen persons attended the Meeting. Appendix B lists the participants and their current mailing addresses.

Invited to the Meeting, but, unable to attend was Kennedy Reed, President, National Society of Black Physicists. Appendix C contains a copy of his letter written to one of the Co–Chairs.

These Proceedings will be distributed to all council members of the Edward Bouchet–ICTP Institute, meeting participants and certain other interested parties.

Finally, it should be indicated that funding for this Meeting was obtained by a grant

from the Office of Naval Research. This grant was to Clark Atlanta University with Ronald E. Mickens as Principal Investigator. A particular vote of thanks and gratitude goes to Michael F. Shlesinger, Director, Physics Division, Office of Naval Research, for his strong support and help in securing this grant.

Ronald E. Mickens
Atlanta, Georgia
April 10, 1992

PROGRAM

Working Meeting of the American Sited Members of the

Edward A. Bouchet – ICTP Institute

PLACE: Paschal's Motor Hotel
Atlanta, GA

DATE: 28–29 March 1992

*** All sessions are to be held in the Matador Room. ***

Co-Chairs of the Meeting
Charles Brown and F. K. A. Allotey

FRIDAY, 27 March 1992

- All day: Arrival of Participants
- 7–9 PM: Informal Reception/Registration
  Room 101

SATURDAY, 28 March 1992

7:00 – 8:30 AM: Breakfast
8:00 – 9:00 AM: Registration (Matador Room)
9:00 – 9:30 AM: Welcoming Session
9:30 – 11:00 AM: Session I – Research at Selected African Universities and Centers
Chair: Sekazi K. Mtingwa
North Carolina A and T University
Main Speaker: F. K. A. Allotey
University of Michigan and
University of Science and Technology
(Kumasi, Ghana)

11:00 – 11:15 AM: Break
11:15 – 12:45 PM: Session II – African and African-American Business Interactions in Science and Technology
Chair: Robert H. Bragg
Lawrence Berkeley Laboratory
Main Speaker: Kwame Boakye
AT and T Paradyne

12:45 – 2:30 PM: Lunch
Speaker: Shirley A. Jackson
Rutgers University
"Some Fundamental Problems in Science and Technology"
2:30 – 4:00 PM: Session III – Issues Related to the Graduate Education of African Students in the United States
Chair: Anthony M. Johnson
AT and T Bell Laboratories
Main Speaker: James Turner
Hampton University

4:00 – 4:15 PM:	Break
4:15 – 5:45 PM:	Session IV – Scientific Personnel and Equipment Exchanges Chair: Abdulalim Shabazz Clark Atlanta University Main Speaker: Charles Brown AT and T Bell Laboratories
5:45 – 7:30 PM:	Break
7:30 – 9:30 PM	Dinner Speaker: Kofi Bota Clark Atlanta University "Are We on the Threshold of a Pan-African Cooperation in Science and Technology?"

SUNDAY, 29 March 1992

7:00 – 9:00 AM:	Breakfast
9:00 – 10:30 AM:	Session V – Funding the Bouchet-ICTP Institute Chair: Charles McGruder Fisk University Main Speaker: Joseph Johnson, III Florida A and M University
10:30 – 10:45 AM:	Break
10:45 – 12:15 AM:	Session VI – Research Opportunities in the United States Chair: Milton D. Slaughter University of New Orleans Main Speaker: Sekazi K. Mtingwa North Carolina A and T University
12:15 – 12:45 PM	Summary/Closing

Physics Research at Selected African Universities and Centers

F. K. A. Allotey
President, Society of African Physicists and Mathematicians
and
Director, African Office, Bouchet-ICTP Institute

March 20, 1992

1 Introduction

In trying to discuss the topic, I shall tie it up with the larger question, why study physics in Africa? In response to this, it is fair to say that our contemporary society can rightly be described as a scientific and technological age. Consequently, national development can hardly be conceived and implemented without the integration of science and technology into it. The strength of a nation and the well being of its citizens is determined most strongly by its technological and scientific development and economic activity. In fact, a nation's progress is determined mainly by how well its citizenry is scientifically literate. There should be a pool from which scientists, medical doctors, agronomists, engineers, and technical personnel would be available.

Africa, with a population of about 550 million people, is the least scientifically and technologically developed continent. The effect of this is reflected in poor medical services, inadequate food supply, poor communication, and in general poor quality of life and short life expectancy. It is recognized that the developmental gap between Africa and the rest of the world is mainly a scientific and technological gap.

According to the 1986 UNESCO Statistical Yearbook, of 3.7 million Research and Development Scientists and Engineers (RDSE's) in the world, just over 10% work in developing countries as a whole, and only 0.4% in Africa, 0.4% in Arab countries, and 2.4% in Latin America.

In more graphic terms, while the number of RDSE's in the third world per million of population is 125, it is only 52 in Africa, 284 in Asia, and 287 in Latin America. The need for active devlopment of science and technology in Africa cannot be overstressed.

Physics forms the basis of most of the natural sciences and technology, and hence, for Africa to participate in the ongoing scientific and technological activity, it is very critical that physics be fully integrated into its educational program.

2 Brief History of Physics in Africa

Historically, the study of natural sciences, and in particular physics, in Africa, excluding South Africa, is recent, and as a consequence African scientists have a rather low level of scientific and technological tradition from which to make an impact. In Ghana, Nigeria, and Sierra Leone, for instance, science education began only about seventy years ago. It is even much later for other countries in subsaharan Africa. At the higher level, in the universities, the history of science education in Africa spans a period which is much shorter. Table 1 shows universities in Africa up to 1950. It is worth pointing out that though the University of Sierra Leone was founded in 1826 as Forah Bay College and is thus the oldest university in subsaharan Africa, it produced its first graduate physicist locally in 1973.

A serious study of physics in subsaharan Africa began in 1948 after the establishments of the University of Ibadan, Nigeria and the University of Ghana, Ghana. It is worth noting that most of the present universities in East Africa, Southern Africa, Central Africa, and West Africa were founded in the late 50's and 60's just before or after these countries gained political sovereignty from their colonial masters. Nigeria alone now has over 30 universities. The majority of people trained in Europe and the U.S.A. during the colonial days studied professions required to run and govern colonial administration: lawyers, bookkeepers, clerical officers, medical doctors, anthropologists, religious men, etc. Low priority was given to science educators. In Ghana, for example, the first person to obtain a B.Sc. in physics did so in 1948 in England. Excluding Egypt, the first group of people in Africa to obtain the Ph.D. in physics came to the science about 25 years ago, all after independence.

3 Organization of Physics Research in Africa

Almost all research in physics in Africa is done at the universities, atomic energy centers, and national research centers. They are all funded albeit inadequately by their governments. Multinationals doing business in Africa do not fund research in Africa. Many international agencies do not fund research in physics as they consider it a luxury for African scientists to engage in physics teaching and research.

4 Solar Energy

Africa has abundant solar radiation throughout the year. It is therefore not very surprising that there exist several active solar energy research centers. Nigeria has two large centers, one at the University of Sokoto in the northern part of the country and the other at the University of Nigeria, Nsukka. Ghana has a national energy research group which is located at the University of Science and Technology Kumasi. Other centers for solar energy research exist at the Universities of Senegal, Dakar, and the University of Zambia, Lusaka. There are also research centers in Egypt, Libya, and Algeria.

5 Nuclear Physics

In terms of International Atomic Energy Agency (IAEA) technical assistance programs, Algeria, Egypt, Ghana, Libya, and Zaire have the largest nuclear research activities.

Egypt has a 2 Mw swimming pool research reactor that was provided by Russia.

Zaire has a 1 Mw Triga Mark II research reactor with pulsing capabilities up to 1,600 Mw.

Libya within the last few years has acquired a 10 Mw reactor from Russia.

Morocco has a slowpoke reactor

Ghana is currently installing a slowpoke reactor obtained from China through the assistance of IAEA.

Nigeria has bought, though not installed, a Van de Graaf accelerator.

All the nuclear reactors in Africa are operated under the IAEA safeguard regimes. Senegal has established a nuclear research center at the University of Dakar. One should also mention the Nuclear Research Laboratory at the University of Madagascar.

Egypt also has a semi-commercial gamma radiation facility located at their National Radiation Technology Center, which is a regional radiation center for Arab countries.

Ghana is completing within a year a semi-commercial gamma radiation facility.

Research programs at these nuclear research centers, we may mention, are centered around

1. Nuclear analytical techniques and applications, neutron activation analysis, x-ray flourescence analysis, uranium prospection, geochronology
2. Health physics/medical physics
3. Environmental studies
4. Nuclear applications in medicine
5. Control of insects of agricultural and medical importance
6. Radiation technology program, food and seed preservation, sterilization of medical products, and polymerization of wood
7. Radioisotope applications.

While waiting for the installation of the slowpoke reactor and the multipurpose gamma radiation facility, Ghana Atomic Energy Commission has the following equipment and facilities around which research is done.

1. A California-252 neutron source
2. A neutron activation analysis facility (A 20 curie Americium-Beryllium)
3. An x-ray flourescence spectrometer

4. a mass specrometer for geochronological research

5. Facility for nuclear track detection

6. Cobalt-60 source for gamma rays.

6 Optical Physics

With financial and scientific support from the International Center for Theoretical Physics, two centers of excellence are being established, one in Ghana for anglophone countries and one in Senegal for francophone countries.

The laser research centers are meant to undertake research projects that are relevant to the West African subregion. It is also envisaged that these centers will conduct post-graduate studies and *turn out* well-trained personnel in areas of optical physics that can be applied to medicine, environmental sciences, opto-electronics, and industry.

Common areas that can be of prime importance are as follows:

1. METROLOGY. The use of research methods such as laser light scattering, lase Doppler velocimetry, and speckle phenomena for

   (a) monitoring water and air pollutions, local drinking water, local industrial products, nuclear tracks, and blood flow

   (b) meteorological studies on soil erosion

   (c) holography and interferometric methods in the study of fracture and corrosion materials.

2. OPTO ELECTRONICS AND INSTRUMENTATION. Fabrication of nitrogen and dye lasers for laser diagnostics of local agricultural products and for the production of fiber sensors for ordinary use , as well as for telecommunications.

3. SPECTROSCOPY. The use of laser induced fluorescence and laser spectroscopy in analyzing extracted tropical medicinal plants and other minerals.

4. OPTICAL WORKSHOP. For assisting the laboratory in making prisms, lenses, and mirrors, as well as supplying research institutes in the country.

5. EDUCATION. To serve as a resource center for educational training for technical personnel and to provide research opportunities for simple projects.

In 1991 an international workshop on laser physics ws held in Senegal. The next wrkshop will be held in Ghana in 1993.

7 Condensed Matter Physics and Materials Science

Universities in Egypt, Nigeria, and Ghana have programs.

8 Earth Sciences and Environmental Physics

Nigeria and Egypt have the largest research programs in Earth Sciences (geophysics, meteorology, and ionospheric physics). I Nigeria the following universities are very active in this area of research: the University of Lagos, University of Ilorin, University of Ibadan, University of Nigeria (Nsukka) and Ahmado Bello University. The University of Khartoum, Sudan, has a regional center for desert studies.

The Society of African Physicists and Mathematicians (SAPAM) organizes international workshops every two years on the "Applicability of Environmental Physics and Meteorology in Africa." The first two were held at the University of Addis Ababa, Ethiopa, in 1987 and 1989. The 1991 workshop was held in Nairobi, Kenya, and will be held there again in 1993.

9 Medical Physics

Some universities in Africa are conducting research in medical physics using ultrasound and radioisotope techniques. The Society of African Physicists and Mathematicians hosted the first African International Conference on Ultrasound in Medical Physics in Ghana in 1989. It was attended by more than fifty people.

10 Regional Centers

Recently, with financial assistance from the government of Italy, the Iternational Centre for Theoretical Physics has created the following centers. The centers are provided with $5,000 each per year for five years by the ICTP. The centers are:

1. National University of Côte d'Ivoire, Abidjan, Côte d'Ivoire.

   Research areas: Theoretical physics, mathematical physics, applied mathematics, mathematics.

2. University of Benin, Cotonou, Republic of Benin

   Research areas: Theoretical physics, mathematical physics, applied mathematics, mathematics.

3. King Mohamed V University, Rabat, Morocco.

   Research areas: Mathematical physics, theoretical physics, particle physics.

4. University of Khartoum, Khartoum, Sudan.

   Research area: Desert studies.

5. National Mathematical Center, Abuja, Nigeria.

   Research area: Mathematical sciences.

11 Society of African Physicists and Mathematicians (SAPAM)

This society was founded in 1983 and is pan-African. Since its inception, the society has organized several activities in many parts of Africa, from condensed matter physics to atmospheric physics.

The aims and objectives of SAPAM are:

- To promote and further education and research in physics and mathematics and their applications in order to enhance technological, economic, social, and cultural development of Africa.
- To promote effective contacts and cooperation among African physicists and athematicians.
- To c~llaborate with national and international organizations with similar objec.ives in furthering scientific and technological activities in Africa.

12 Problems Affecting Physics Research in Africa

At a pan-African physics congress, which over 100 African physicists attended in 1984, the following problems were identified as mitigating against physics research and teaching in Africa.

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12 Problems Affecting Physics Research in Africa

At a pan-African physics congress, which over 100 African physicists attended in 1984, the following problems were identified as mitigating against physics research and teaching in Africa.

1. Inadequate student numbers
2. Shortage of qualified teachers
3. Lack of critical mass for effective research
4. Poor experimental facilities
5. Shortage of technicians to maintain equipment
6. Shortage of textbooks, reference books, and journals
7. Inadequate interaction among physicists
8. Lack of adequate recognition and support by home governments
9. Unfavorable economic conditions
10. Poor communication

I hope that, with the establishment of the Bouchet-ICTP Institute, our brother African-Americans will assist African physicists in solving some of these problems.

TABLE I

Country	University	Year
Algeria	Université D'Alger	1879
Egypt	Ain Sham University University of Cairo University of Alexandria America University of Cairo	1950 1908 1942 1959
Ethiopia	Addis Ababa University	1950
Ghana	University of Ghana	1948
Liberia	University of Liberia	1862
Morocco	Université Quaraonyine	859
Nigeria	University of Ibadan	1948
Senegal	University of Dakar	1949
Sierra Leone	Fourah Bay College	1827

SAPAM PAST ACTIVITIES

1984	October	Trieste, Italy	Symposium on state of Physics and Mathematics in Africa
1985	July	Abidjan, Cote D'Ivoire	Symposium on functional analysis and its application
1986	July	Abidjan, Cote D'Ivoire	Symposium on group theoretical methods and its applications
	September	Nairobi, Kenya	Workshop on Curriculum Development and Design in Physics, Mathematics and Computer Science
	December	Kumasi, Ghana	International Seminar on Renewable Energy
1987	April	Yamoussoukro, Cote D'Ivoire	Symposium on Mathematics and Computer Science Education
	May	Freetown, Sierra Leone	College on Material Physics
	July	Abidjan, Cote D'Ivoire	Symposium on Computer Science and Numerical Analysis
	August	Addis Ababa, Ethiopia	First Workshop on the Applicability of Environmental Physics and Meteorology in Africa
	September	Bujumbura, Burundi	College on Mathematical Physics
1988	January	Monrovia, Liberia	Workshop on Teaching of Physics at Secondary School level
	April	Kumasi, Ghana	Kumasi College on Renewable Energy
	July	Abidjan, Cote D'Ivoire	4th Abidjan Symposium of Mathematics on Differential Geometry, Mechanics and Physics
1989	July	Kumasi, Ghana	First International Workshop on Ultrasound in Medical Practice
	August	Addis Ababa, Ethiopia	Second Workshop on the Applicability of Environmental Physics and Meteorology in Africa
	December	Ilorin, Nigeria	International Workshop on Advances in Communication Physics and Techniques
	November	Kumasi, Ghana	Kumasi College on Renewable Energy
1990	August	Accra, Ghana	The Second Bouchet International Conference on Physics and High Technology for the Development of Africa through the 1990's
	November	Kumasi, Ghana	Kumasi College on Renewable Energy.

WORKING MEETING OF THE BOUCHET COUNCIL

Session I: "Research at Selected African Universities"

Session Chair: Sekazi K. Mtingwa
Department of Physics
North Carolina A&T State University
Greensboro, North Carolina, U.S.A.

Main Speaker: F. K. A. Allotey
Departments of Physics
and Electrical Engineering
University of Michigan
Ann Arbor, Michigan, U.S.A.
and
University of Science and Technology
Kumasi, Ghana

March 28, 1992

Summary

Professor Allotey summarized some of the practical results which have been achieved since the Second Bouchet Conference which was held at the University of Ghana, Legon in August, 1990:

From Africa

- 3 graduate students at Hampton University
- 1 graduate student at Clark Atlanta University
- 1 graduate student at the University of New Orleans
- 1 student at the City University of New York

From U.S.A.

- 1 American Professor made a member of the Ghanaian Atomic Energy Commission
- 1 American Professor gave the 1990 DuBois-Padmore-Nkrumah Lectures in Ghana
- 2 American Professors invited to Nigeria
- 1 American Professor invited to Benin
- 4 American Professors invited to Senegal
- 1 American Professor gave a series of lectures on optics in Ghana

The first question broached by Professor Allotey was "Why do physics in Africa?" His answer was that physics, and science and technology in general, contribute to the well-being of each society in this highly technological modern world. He further stated that the most technologically advanced countries understand this. Thus, the developmental gap between Africa and the rest of world is mainly scientific and technological and it is now realized that science and technology are important in efforts to

- Improve the quality of life
- Provide a sound base for economic and social development
- Modernize national economies
- Participate more actively and equitably in international trade
- Create a firm basis for employment opportunities and wealth

Professor Allotey mentioned that Africa is a diverse continent, having over 550 million people and some 880 languages. In Nigeria alone, there are 120 million people and over 300 languages. It was generally agreed that, regardless of their language or ethnic group, all science students graduating from African universities should be able to hold scientific discussions in English, since that is the most universal language for communicating science and technology.

Professor Allotey gave a bit of the history of the evolution of universities in Africa. In some countries, science education is less than 70 years old. There were only nine universities in Africa before about 1960. The British originally created only one university to serve Nigeria, Gambia, and Sierra Leone. Most other universities were founded after the independence movements, which started around 1960. The first B.S.E. degree obtained by a Ghanaian was in 1948, but the student had to go to England for the degree.
The first African to receive a doctorate was an Egyptian in 1926, who received it from a university in London. Up until recent times, even though students had worked on their doctorates in African universities, their degrees were awarded by the "parent" universities in Europe. Nowadays, a student can fully study and obtain doctorates from African universities; however, they must pass external examining committees which are remnants of the European system. In general, African students at the university and secondary school levels have been hampered by having to pass entrance and other standardized exams which have been firmly rooted in European culture and tradition.

Professor Allotey gave a brief overview of the research facilities available in Africa. He stated that the best such facilities are located in Algeria and Egypt. The state of the facilities in most African countries is such that students doing experimental work for the doctorate must usually go abroad to perform their experiments.

This session of the Bouchet Working Meeting was a lively one, and the information and insights which Professor Allotey provided were greatly appreciated by all in attendance.

African and African-American Business Interactions in Science and Technology

Kwame A. Boakye
AT&T Paradyne
Largo, Florida 34649

Abstract: This paper discusses the motivation for, areas to be focused on and the mode of business interactions between Africans and African-Americans in science and technology. It first suggests that in addition to the emotional ties, there are other concrete underlying reasons for providing a win/win situation across the Atlantic. With that basis, the area of knowledge-intensive science and technology which require minimal capital investment is suggested as one for immediate focus. In particular, information technology should be targeted. Also suggested is telecommunications which, in addition to being symbiotically related to information technology, can be actively promoted in the existing business environment because of the complementarity to services required to effect globalization in the technologically advanced world. To exploit these opportunities, various ways of interaction are suggested: joint business ventures, exchange of professionals, and increased economic interaction. All these need to be supported by improved education to bridge the cross-Atlantic cultural gap.

1. Introduction

The potential of science and technology (S&T) as a catalyst for development has long been recognized as enormous. Yet, its coexistence with the poverty, hunger, illiteracy, unemployment, disease, and in general, underdevelopment, is a reality throughout much of the developing world. Not much of this potential has been systematically applied to the problems of the developing countries. Although much concern has been expressed about how S&T may be judiciously applied to these problems in which social and human factors are of such importance, the coexistence of enormous scientific and technological potential in the developed countries with vast and growing unmet needs of the developing countries is a contradiction, not only of the basic laws of supply-and-demand, but also to the professed international aspirations toward the uplifting of human existence. To remedy this moral dilemma, various international efforts such as the *Vienna Programme of Action on Science and Technology for Development*[1] have aimed to help create the infrastructure upon which S&T can be fully exploited for development.

With respect to Africa, the foreword to the United Nations' *Programme for the Industrial Development Decade for Africa (IDDA)*[2] which was one of the outcomes of the Vienna Programme of Action read thus:

"The standard of living in Africa today is [among] the lowest in the world, so much so that that the vast majority of the people in the region lead a meagre existence. Their chances of a better future are endangered by the increasingly unsettled international situation and a persistent world economic crisis. Africa is also threatened by a food and energy crisis, the impact of which is aggravated by poor economic management: this, in turn, worsens the region's external debt burden and balance of payments problems ..."

The above report went on further to suggest that: to increase the likelihood of success for the implementation of the IDDA, there must be affirmative steps to stimulate the economic growth of Africa from within. This would, in turn, initiate "a process of internally generated, self-sustaining growth through an integrated development strategy which links industry with agriculture, energy, human and physical infrastructure, trade and other sectors."

To promote this bootstrap approach, the United Nations and its agencies, together with the OAU and a number of other international organizations embarked on various programs and projects in

S&T to promote development in Africa. While these programs attained their targets to varying degrees, the ultimate success metric ought to be how much they helped to alleviate the conditions they were designed to tackle. The above situation described in 1982 is largely true today; the economic condition in most of Africa today is not bright.

Even so, the focus that was thrown on the potential for using S&T for development helped to increase the general awareness of the importance of S&T as a development tool in Africa. As a result, efforts were undertaken to increase the endogenous capacity for the utilization of S&T in many countries. This created a cadre of S&T professionals who could form the basis of any thrust to exploit S&T for development.

In the mean time, on the other side of the Atlantic, in particular, the U.S., some major changes were taking place among people of African descent. First, there has been an increased focus on S&T as an area of rewarding career opportunity and resultant improved economic well-being for African-Americans. This was partly the consequence of the general emphasis in the U.S. on the importance of S&T to national competitiveness; it was also fostered by the improved opportunities for African-Americans to enter institutions which provide support and reward for S&T. The improved capacity and talent pool in S&T in the African-American community is a competitive asset and represents value: a major source of expertise to be tapped in any development effort. That value, like other values in the increasingly competitive world market, is seeking avenues for maximum leverage and impact.

While the skill level in S&T was increasing, there was a concomitant shift in perspective. There has been increased awareness in the African-American community of the importance of Africa not just as source of heritage but also a potential area of economic and other opportunities.

With this convergence of need, skills and perspective, it is only natural to ask how the needs and resources of Africa and the S&T resources of African-Americans can be married for mutual benefit. While this potential synergy has obvious intellectual and emotional appeal, to translate it to reality, one must confront some major issues. Among them is a clear articulation of the basis for any such interaction. In the final analysis, why would anyone expend precious energy in pursuit of such a goal? Is it possible to create a sustainable win/win situation? This is addressed in the next section.

Having satisfied oneself that such is a worthy cause, one must then identify the areas of focus. With the myriad of possibilities, it is all too easy to overstretch one's resources to the point of ineffectiveness. What resources are required to make such an enterprise successful, and can those resources be marshalled? As shown in Section 3, there are areas which can be targeted without the usual major capital expenditure which tends to become an obstacle to success. Where significant capital must be involved, areas which can leverage off services needed in the developed nations may be able to ride the wave of the new globalization thrust.

Finally, having delineated the scope, the mode of execution must be defined. What steps must be taken to ensure that there will be a sustained effort in promoting the interaction. That is the subject of Section 4 where it is argued that success requires that any such interaction must be promoted and architected to become part of the day-to-day business environment. If considered "special", it is likely to be near the top of the endangered activities list whenever priorities call for retrenchment.

A word of caution is in order here. Africa is is a diverse continent with 53 countries of varying economic and other means, hundreds of millions of people of varying ethnicity. Accordingly, it can be misleading, if not dangerous, to attempt to characterize the whole continent in general terms. The observations made here will apply to the majority but by no means all the countries.

Therefore, as long as the discussions in this paper are tempered by this realization, they will be meaningful.

2. Motivation for Interaction

2.1 The Common Bond

The over-riding consideration for the coming together of African peoples is the common bond of race which others have, from time to time, used as a weapon against the group on a global scale. Today, the potential and achievements of any person of African descent are largely overshadowed by the inability of the group as a whole to be sufficiently recognized on the global scale as a compelling competitive factor. It is this author's thesis that this adverse state-of-affairs can be overcome only when one or more African nations get recognized on the global level as a major economic force. As an existence proof one may point to the recent increasing admiration/antipathy that the West has developed toward Japan. The erstwhile feeling of superiority on the part of the West is being supplanted by one of fear, if not an outright inferiority complex. How often do we hear, even in the technical community, how smart Asians are? Regardless of the merit of such notions, it is clear that the recent economic force of Japan and the rise of other countries such as Taiwan and Korea have helped to shape such perceptions.

This impediment to self-actualization imposed (whether fairly or unfairly is irrelevant) by the present limitations of Africa on the contemporary global scene is, in itself, a major motivating factor for all people of African descent to work together to promote the advancement of strategic parts of the continent, if not the whole continent.

2.2 Supply and Demand Considerations

While the need for self-esteem and recognition provide the basis for coming together of the disparate African groups, these emotional reasons are generally insufficient to overcome the many obstacles to capitalizing upon the latent bond to generate a set of activities to benefit the group in a sustained manner. Other factors must be found. One comes from the classical economic principle of supply and demand. Africa has a demand for S&T for development; African-Americans, as part of the developed technological world of the U.S., are well positioned to help supply the expertise. African-Americans seek greater recognition and more avenues for entrepreneurial drive leading to a good return on invested energy; the utilization of their skills in Africa could help meet those needs. Their contribution can be effected directly or by helping to influence the general business climate in the U.S. on the importance of interactions with Africa. As the majority of U.S. business looks to Eastern Europe, with the opening up of the Eastern Bloc as a new frontier of market opportunity, African-Americans may find a niche in Africa.

The state-of-affairs in Africa is now briefly examined to further show the demand for S&T for development. As noted above, the economic situation needs to be significantly improved. All the usual measures of indicators of economic and social progress paint a very challenging picture. For example, according to World Bank reports, the per-capita gross National Products (GNPs) are among the lowest in the world, the infant mortality rates are among the highest while the general education level as captured by the school enrollment and literacy rate are among the lowest. Table 1 from World Bank publications[3] [4] help to describe the social and economic conditions. According to these figures, while a few countries appear to be managing, for the vast majority, especially in sub-Saharan Africa, the conditions are particularly serious. For sub-Saharan Africa:

- there was a population of about 400 million in 1989 with a growth rate of 2.9%;
- the average per-capita GNP was about $330 in 1989 with about 33% of the GDP coming from agriculture;

- more than 1 out of 10 children born will not live to see age 5 and for those who survive, the prospects for seeing age 60 are not bright;
- only 47% of the population was literate in 1985 even though an increasing proportion of children were being enrolled in school.

It is very discouraging, almost to the point of hopelessness when these statistics are contrasted with comparable ones from the technologically advanced nations – whose statistics are shown in Table 2. Nevertheless, since it is generally recognized that the conditions in these developed nations are far superior, the contrast comes as no surprise. The gravity of the African situation and the need for immediate action becomes particularly evident when the statistics are compared with those of other developing countries. Table 3 gives the social and economic indicators for countries in Latin America and the Caribbean which are also generally viewed as developing, and therefore not an unreasonable benchmark for African countries. Of particular note are the significantly improved infant mortality rates, life expectancy, literacy level and school enrollment rates. A target expectation for Africa to close the social and economic gap, compared with other developing nations, would appear to be reasonable and attainable. Perhaps, the case of the recently industrialized Asian and Latin American countries may help point the way to how African countries can organize to overcome economic hurdles.

In the face of the above statistics, paradoxically, some of these same African countries have considerable natural and human resources. Minerals abound, even if unexploited. The soil, in many parts, is fertile even though the prolonged lack of effective care is beginning to take its toll. While the human resource is largely unskilled in S&T, the base of S&T is slowly growing; some countries are gaining a reasonable base upon which to build. There is general improvement in education. Many countries have invested in the second and third tiers of education, leading to a steady stream of secondary school and university graduates. Besides, it is now widely recognized that to significantly change the living standards of the people, S&T must be used to good effect. Many of the governments have established the equivalent of Ministry of Science and Technology. These stand ready as the platforms for the conception of ideas and machinery for the deployment of S&T for development if only ways can be found to utilize them.

One country worthy of particular consideration is Nigeria with its considerable resources and market potential. With a population of over 110 million, petroleum and other resources, it is well positioned for economic power. In turn, it could act as the economic catalyst to propel other countries forward. However, this can be realized only through the effective application of S&T. At this point, working with a partner who has access to the S&T resources of the developed world would appear to be mutually beneficial.

With respect to African-American capability, it is first noted that African-Americans are increasingly becoming an integral part of mainstream U.S. business. In addition, the number of African-Americans receiving higher education leading to occupations in S&T is increasing. For example, it is estimated that the number of African-American owned businesses rose 35% between 1982 and 1987 to represent 3% of the total U.S. enterprise[5]. Specific to S&T, whereas less than 1% of the graduating engineers in 1971 were African-American, it rose to about 4% in 1991. Also, it is estimated that African-Americans represent 3.6% of engineers (of all types, graduate and non-graduate), 4.3% of physicians and 5.7% of computer professionals[6]. Table 4 gives some statistics on some relevant occupations. While these numbers do not proportionately represent the African-American population in the U.S. and there are efforts under way on many fronts to improve them, they show a significant source of entrepreneurial drive and growing capacity in S&T; 3% of U.S. enterprises is significant by measures in other parts of the globe. It is further observed that businesses in telecommunications, computers and other high technology areas are on the rise. They have started appearing in increasing numbers on the *Black Enterprise* top 100 businesses[7], showing the increasing importance and capacity in S&T.

The African-American growing capacity in S&T can find applicability in Africa where opportunities exist for entrepreneur partners to participate in improving the lot of the people and changing the above social and economic statistics. While the problems may appear immense and almost intractable, it is possible to identify a set of areas which underly the problems such that any solution to them will, in turn, promote the solutions to other problems. One may view these as the *eigenvectors of development.* Economic and social development requires improved agriculture, effective utilization of mineral and other natural resources and availability of energy supported by an education and communications infrastructure. These will be the prime focus of this discussion. Other areas such as food and health are clearly important. However, by solving the problems related to the primary areas, problems of the others get solved. For example, the alleviation of food problems is strongly dependent on more productive agriculture and improved education on nutrition.

2.3 Areas of Opportunity

With respect to Africa, agriculture is the basic industry, employing about 70% of the labor force[8]. Agriculture accounts for a large share of the economies of the various countries and any development on that front is bound to have a significant impact on the whole economy. Success there will, at least in the near term, largely determine the economic growth and help to improve life in rural areas where the majority of the people live. Food, in turn, is needed to alleviate malnutrition, improve health and create a more productive work force. However, in the absence of general economic growth, it is difficult to have sustained progress in the fight against malnutrition. Increasing growth and the competitiveness of the economy may be the best way to reduce malnutrition and poverty since a growing and competitive economy tends to promote a more even distribution of human capital and other assets, thus, facilitating improved living conditions for the poor.

Mineral and other natural resources generally form the raw materials for heavy industry which tends to position a nation favorably for maximum benefit from S&T. However, to exploit these natural resources, energy is needed. Energy is also required for the enjoyment of any reasonable level of modem life.

Education is needed to improve the availability of skilled manpower to carry out administrative, technical and managerial tasks as well as to create a citizenry that can actively participate in the life of the nation, in light of the complexities of modern governance.

Communication in the modern world has become synonymous with telecommunications infrastructure. Telecommunications has now become the ether through which commerce flows. It is difficult to imagine any economic transaction without communication and with the globalization of the world economies, it would be difficult for any nation to survive without an effective telecommunications infrastructure. Much has been written about the benefits that telecommunications can offer developing nations, in terms of improving the productivity and efficiency of rural agriculture[9]. Indeed, there appears to be a strong correlation between economic development and telecommunications. This is illustrated in Figure 1 which shows the relationship between the per-capita Gross Domestic Product (GDP) of some developing and recently developed countries in Africa, Asia and Latin America and telephone density[10]. A correlation between the per capita GDP and telephone density is evident. This is particularly true for the lower GDP levels where most of the Afrcan countries presently are.

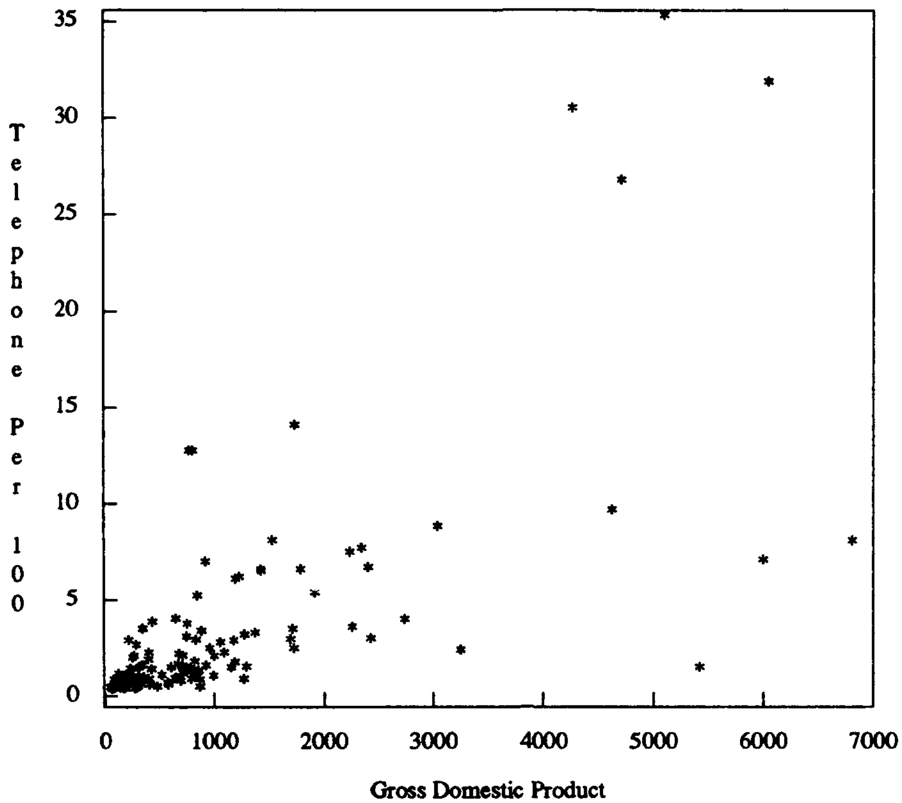

Figure 1: GDP and Telephone Density for Developing Countries

In summary, the opportunities in agriculture, mineral and other natural resources, energy, education and communcations would appear to offer considerable opportunities for the application of S&T in the development of Africa. Given the desire for self-actualization gained through the general uplifting of the global image of people of African descent and the avenue for entrepreneurial drive, using S&T for the development of Africa should be of interest to African-Americans. Complementarily, with African-Americans as a potential beach-head into the U.S. world of capital and technological know-how, they should constitute a partner of choice for African nations eager to radically alter the present economic picture.

3. Areas of Interaction

3.1 Areas for Consideration

In considering where to focus in the business interaction between Africans and African-Americans in S&T, the issue becomes how to achieve maximum impact from realizable resources. First, it is noted that the field of S&T is very broad and many activities come under the umbrella. These range from basic cottage industries to sophisticated leading-edge research in areas such as high-energy physics, rocket science and superconductivity. Secondly, as noted above, the eigenvectors of development are in agriculture, mineral and other natural resources, energy, education and communication. Thus S&T related to these areas would appear to have the maximum impact.

Another consideration is the availability of capital. At this point, most U.S. industry does not consider Africa to be one of the areas of prime interest. The risk is perceived as too high. The current emphasis is on the Americas, Europe and the Pacific rim. While there should be continued effort to expand this list of priorities, in the near term, much will be gained by concentrating on areas which either may not require significant initial capital outlay or can obviously pay for themselves, and can therefore be promoted much more easily in the existing business context. This would appear to favor S&T areas which tend to be knowledge-intensive without requiring much heavy industry or areas which could complement business needs in the industrialized countries. Among the first are the "light" sciences and technologies which require more "head" than "factory". A leading example of the latter is telecommunications.

3.2 The Knowledge-Intensive Technologies

3.2.1 The Applicability of Knowledge-Intensive Technologies

The "light" sciences and technologies give rise to what may be described as *Knowledge-Intensive Technologies (KITs)*. These are similar to the so-called *New and Emerging Technologies*[11][12][13][14], *Advanced Technologies* or *High Technologies*. The ones considered here are Information Technology (IT) which is closely related to telecommunications, Biotechnology, New and Renewable Energy and Remote Sensing. These technologies have been the consequence of the intense accumulation and dissemination of knowledge arising from the rapid developments and innovations which have characterized the state of S&T during the last quarter century. While they may require significant capital for research, development and manufacturing of the products resulting from them, their application does not always require a very sophisticated development base. Very importantly, they have promoted entrepreneurial drive and opportunities for many start-up companies.

The emergence of these technologies has been strongly dependent on IT which itself has been a primary beneficiary of the advent, increasing versatility and ubiquity of computers. With the immense processing and storage power possible with computers, complex analyses and simulations have become possible and experimentation has been greatly facilitated by the building of computer models in place of prototypes that would have been costly and time-consuming to realize. Therefore, IT, the technology which has been the catalyst for the development, evolution and effective utilization of the KITs, is of particular interest. It could play a similar catalytic role in the adaptation and application of S&T for development in Africa.

The governments of many industrialized countries, recognizing the lasting impact of these technologies, have embarked upon their active promotion and commercialization. The approaches have been through the direct and indirect support of research and development (R&D) as well as through the creation of incentives. The private sector has also been very active in research, development and commercialization through the provision of venture and seed capital.

In Africa, as indeed in much of the developing world, however, there appears to be no coherent process for taking advantage of the potential benefits of these technologies[15]. Rather, in some countries, there is some apprehension of greater technological dependence. Yet, some of these same technologies could, potentially, provide the opportunity for these countries to leapfrog in the development process. While cautioning that there exists a threshold of competence required to realistically deal with these technologies, it must be pointed out that the entry cost for their application, in terms of investment, is in some cases relatively modest. The application, of course, should be contrasted with the cost of advancing the technology which is generally significantly higher.

3.2.2 Opportunities in Information Technology

Information Technology refers to the set of technologies underlying information movement and management (IM&M). It is the consequence of the marriage of telecommunications and computers which has resulted from the electronic revolution. Microelectronics technology has made computers more powerful, widely available and easier to use, and revolutionized telecommunications.

IT is a three-tier technology of increasing user perceptibility. At the base is micrelectronics which produces the basic elements such as microprocessors and digital signal processors. Typically, these elements are incorporated into the fabrication of systems or engines which provide the horse power for the movement and management of information. The prime example is the computer. Microminiaturization has ushered in the mini- and microcomputer, bringing tremendous processing power to the office and desk-top for relatively little cost. The top or application tier of IT consists of exploiting the power of the resulting machinery to solve problems which most users perceive. This is the most visible part of IT and forms the cornerstone of the Information Age. It involves the use of the resulting systems – especially, the computer – in conjunction with application programs to handle various user-oriented information systems. It covers computer-based techniques, information systems, data banks, etc. and lies at the core of promoting the transfer and facilitating of the development of other technologies.

Software is a major component of the application tier. It is this software that allows computers and other intelligent devices to perform specific functions in the realization of user applications. Word processors, data base management systems, air traffic control systems, telecommunications systems, automated factory systems, electronic fund transfer system, information retrieval systems would all be incapacitated without the software. It is noteworthy that whereas considerable sophistication is required for the production of the hardware (the lower two tiers), beyond the basic skills required to utilize a computer, a familiarity with the problem being solved becomes the critical requirement for the development of software. Thus, the utilization of IT, does not depend as much on a solid industrial base with manufacturing capacity. On the contrary, it is manpower-intensive, albeit highly trained manpower. Thus, for a country which has already invested reasonably in education, given the falling prices and the consequent affordability of microcomputer equipment needed for training, the incremental cost to exploiting IT would seem to be a reordering of priorities to emphasize the importance of the computer and the creation of incentives for its utilization. Also needed, would be a concerted national effort to apply such techniques to the development of the infrastructure and potential leverage off that to provide services to other parts of the world.

IT is particularly important for two reasons. Firstly, it is a catalyst for the application of the other technologies. The capture, storage, processing and dissemination of the knowledge that is central to all the technologies can be most effectively handled through the application of IT. Also, since the incremental investment cost for its utilization could be relatively modest, many African countries could begin to use IT to great advantage, immediately. This, in turn would facilitate the utilization of other technologies. Since a key requirement to the use of IT application is familiarity with the problem, this is one area in which local solutions could provide an edge if resources were properly marshalled. However, to reap the benefits of IT application, trained manpower is essential. This implies the planned development of human resources and a re-orientation in the curricula of the educational system to emphasize IT. Also needed would be a reasonable telecommunications infrastructure.

The starting point for IT application is to help in planning by facilitating the analysis of data to produce information for decision making. Secondly, any reasonably complex business transaction similarly requires the efficient movement and management of information, the very essence of IT. Application software and systems to help the smooth running of many of the institutions such as banking, transportation, office and factory management, government planning, statistics, census and other operations would be a significant aid in transforming the economies of many African countries.

The expertise gained in efficiently capturing, processing and transmitting data can be leveraged elsewhere. As observed earlier, there are parts of IT such as data processing and software development that are still labor-intensive. For example, there is still considerable data entry that must be done by businesses in developed countries. Therefore, if African countries can develop the requisite expertise, their lower labor cost could be used to advantage. A graduate in Africa earns only a small fraction of what his/her U.S. counterpart will command. For example, a U.S. graduates in computer science/engineering will earn well over $35,000 a year with a loaded salary far in excess of $75,000, their African contemporaries earn less than 10% of that. Similar relative comparisons hold for other levels of education. Thus, for companies looking to save, it may be advantageous to set up data processing and software development "factories" in Africa. Alternatively, such operations could be outsourced to a service provider who, in turn would operate the "factories" in Africa. Of course, for such an undertaking to be considered satisfactory, there will have to be appropriate quality control and a good telecommunications link. This is an area where with a concerted African and African-American entrepreneurial partnership, an arrangement in which everybody wins can be realized.

3.2.3 Opportunities in Biotechnology

Biotechnology consists of the utilization of the biosciences in the manipulation of micro-organisms, as well as animal and plant cells to produce a variety of products, including foods, chemicals, medicines and industrial enzymes[16][17][18]. Fermentation techniques – which may be considered a component of traditional Biotechnology – have been around for a long time, being used primarily for the processing of staple foods. Other traditional techniques have resulted in the high-yielding varieties of crops, and processes for water treatment and purification. Such techniques continue to be of great relevance in many African countries.

Modern Biotechnology emerged within the last 15 years. The use of the computer for complex analyses in the biosciences has aided discoveries in DNA structure, recombinant DNA and developments in genetic engineering. These new advances are leading to the emergence of industries based on genetically engineered materials. While the leading-edge applications have been in the fields of medicine and pharmaceuticals, a potentially wide spectrum of application exists.

The techniques promise to transform agriculture, and also have importance for other carbon-based industries such as energy chemicals and waste management. The potential is enormous because research in the biosciences is making very rapid advances and the results not only affect a range of economic sectors but also promote greater linkage among them. The generation of energy by the fermentation of agricultural wastes, for example, would affect both the energy and food sectors.

As indicated above, agriculture is high priority for all African countries. There is a strong need to increase food production. Consequently, the primary interest in Biotechnology may initially be in the impact on agriculture and increased food production, including the development of species that could be adapted to desertic areas or used to recover regions facing desertification. Other beneficial areas include improvements in animal health and breeding. Also, in the field of human health, vaccines are being developed against a whole array of diseases.

The opportunities which Biotechnology offers in agriculture should be the first area of exploration in Africa. Traditionally, agriculture has been an area of strength for the Historically Black Colleges and Universities (HCBUs). Indeed, many of them were founded with agriculture as a prime mission. This core competence of HCBUs could be leverage both at the level of R&D and commercial enterprise in many parts of Africa.

3.2.4 Opportunities in New and Renewable Energy

The energy crisis of the mid-1970s brought a new awareness of the potential for harnessing other forms of energy besides the conventional petroleum source. As a result, a number of new sources of energy have been investigated and continue to be under serious consideration. The range of activities has gone from the development of completely new sources to the upgrading of techniques relating to already known sources. Such energy sources include biomass, solar, geothermal, wind and ocean energy and nuclear and mini-hydro power.

Development of New and Renewable Sources of Energy involves continuing technological R&D. Nuclear energy has been utilized for electricity generation. However, because of its high capital costs and environmental hazards, it is not likely to be used extensively in developing nations. Mini-hydro projects, are based on relatively recent technological development as compared with the mature and established technology for medium and large hydro stations. Biomass is the most available source of energy and comprises fuelwood, agricultural crops, human, animal and vegetable waste, either in its traditional form or converted ethanol or methanol or biogas. Solar energy can be considered with respect to relatively simple solar collectors which gather sunlight and heat specific fluids (air, water, etc.), and complex photovoltaic technology involving the utilization of the sun's rays for electricity generation through solar cells. Photovoltaic technology can be applied to several conditions and can be particularly useful to meet power needs in remote regions.

Energy technologies will continue to be a field of major innovative development with the focus on reducing cost. The actual utilization of alternative sources will depend, however, on country-specific requirements and technical characteristics of the energy sources. Since socio-economic development is largely dependent on energy availability, it is vital for African countries to produce most of their energy supplies as cheaply as possible. Geothermal energy has been exploited in some areas such as Kenya. However, since such plants can only be located close to geothermal energy sources, this is a major limiting factor. Also, even though operating costs tend to be low, the capital cost is high. Wind energy is also location-specific, has had very limited application and its potential appears equally limited. Mini-hydro power generation has had considerable success in Kenya as well as several other developing countries, including China, Colombia, India, Pakistan and Peru. Conversion of biomass has been undertaken extensively in China and India and appears to be of particular applicability in rural areas. Solar energy is one source that holds a lot of promise for African countries where that source is plentiful. Electricity generation using photovoltaic technology is still the subject of continuous and rapidly changing development. These changes could have a profound effect on the economies particularly, in the rural areas.

By far the greatest area for energy thrust relates to solar power. Collaborative R&D and commercialization will find a ready market in Africa.

3.2.5 Opportunities in Remote Sensing

Of increasing importance is the application of Remote Sensing through which it is possible to see and interact remotely with large parts of the earth simultaneously. This facilitates the acquisition of very valuable data for applications in such areas as agriculture, fisheries, navigation, meteorology and mineral resources. For such uses, the technology needs to be coupled to an appropriate system which can process the data to give the information that is required. IT, therefore, plays an important role in the effective utilization of Remote Sensing.

Remote sensing relies on satellites and other sophisticated techniques which generally require significant capital investment. While the start-up cost is very substantial, the incremental cost tends to be relatively modest. Thus, the technology is very suited to utilization on a regional basis. With the cost shared among several participants, it becomes cost-effective. Moreover, increasingly, many earth station designs provide for solar power and this would further facilitate their use in Africa. Even the relatively large start-up cost which is the main limitation has an inherent advantage since it encourages sharing on regional and international levels, thereby, fostering cooperation. For African countries, the ability to procure data on natural resources could be vital. However, such data becomes useful if the necessary investment has been made in IT to capture, process and transmit the data to facilitate decision making.

The urgency in the application of Remote Sensing lies in the fact that, so far much of the application has been by industries and agencies of industrialized countries. In many cases, this gives them more information on the resources of other countries than these countries themselves have. This imbalance gives substantial advantage to the developed countries which in many cases are the customers of the products of the developing countries. The ability to have independent access to similar data would provide African countries the realistic basis for negotiating with such customers.

Opportunities in remote sensing could lead to major results in mineral exploration. There exists the need for independent consultancy to many African countries on mineral deposits. However, the benefits of Remote Sensing may not be easy to realize. This is because of the restricted access to the technology and the significant capital investment. Moreover, there is considerable competitive trade information which the owners of the technology will like to leverage in their transactions in mineral and other resources. Thus, any success African-American entrepreneurs have in making the technology available would be a major contribution; and given the high degree of interest in the mineral sector in many African countries, the reward would be commensurate.

3.3 Opportunities in Telecommunications

The exploitation of the recent explosion in technology in telecommunications has been one of the major factors underlying the Information Age. By taking advantage of some of the well-established technologies as well as some of the emerging ones, it may be possible to build a cost-effective telecommunications infrastructure. That in turn, may facilitate growth in economic activity which will act as the grease for the development process.

The telecommunications services of prime consideration are voice, data and facsimile. These are considered basic because the initial promotion of economic activity is strongly dependent on the ability of person-to-person transaction and the capability for the efficient management and movement of data which either results from such a transaction or is needed to guide such a transaction. Besides, in these areas the technologies are sufficiently stable to be within the economic and operational reach of many African countries. The importance of visual communications is acknowledged but other than in mass communication, it is considered to be of a lower priority at this point of the development cycle. Furthermore, the emphasis is on building a public network for the provision of the voice, data and facsimile services. Even though private networks could enhance the objective of using telecommunications as an infrastructure for the promotion of economic growth it is, nevertheless, felt that the public network would be most apt for the fastest penetration of telecommunications services in these countries. The reason is twofold. Firstly, for most of these countries, the largest institution – in terms of economic activity and social advancement – is the government and it is unlikely that the government will provide private networks for institutions within the country outside the ambit of the public network. Secondly, since the public is an indispensable component for any social and economic thrust, the institutions for growth must, as quickly as possible, find a way of reaching it; and this is most effectively accomplished through a public network.

Wireless telecommunications systems are of particular interest. In the African environment, many of the limitations pertaining in the developed world, such as the congestion of the air waves and the extreme sensitivity to interference from other electrical signals, will not become significant problems for an appreciable period of time. This permits the use of radio-based technology on a much more extensive basis. Furthermore, the many remote areas coupled with the lagging state of the construction industry which leads to difficulty in laying cables form considerable impediments to the deployment of a conventional telecommunications system. Hence the attractiveness of a wireless system. Such a system can be implemented much more rapidly, thus, facilitating a much faster penetration of service.

In particular, a cellular radio system could be used as a loop elimination technique to provide the access. This solves the problem of access bottleneck to many of the existing networks. The outside plant, where installation and maintenance are key, is typically the least developed part of most African telecommunications networks. Because of limited sharing opportunities, it is the costliest and the most labor-intensive part of the network. Some networks have installed switches, developed some backbone transport using microwave and even satellite. Yet the systems are not very well utilized because the connection to the ultimate beneficiary of any telecommunications system, the customer, does not exist.

Microwave technology, even though mature, continues to be appropriate and gets around the problem of laying and maintaining cables. This is especially important since many African countries lie in the Tropical rain forest region or have mountainous terrain which make such an undertaking very expensive. Of course, these may also represent an impediment to the use of microwave relay systems. Even so, the lower frequency bands, where rain and other weather conditions have relatively little effect, are generally available for use, unlike in the developed countries where these bands tend to be crowded. Moreover, given that availability is not a critical constraint, an occasional downtime may be tolerable, thus, making the system practical without an extensive back-up arrangement. Thus, microwave relay systems are appropriate for deploying as backbone transmission systems on the networks of many African countries.

Given the wide coverage that a satellite can provide and the fact that an earth station can be installed anywhere, satellite communication would appear natural for Africa. This is particularly so since it also skirts around the problem of terrain and other environmental obstacles. Moreover, unlike microwave relay, no repeaters are required thus, further reducing the maintenance requirement. Again since the spectrum is relatively underutilized, there is a choice of frequency bands to optimize for the local conditions. Also, increasingly, many earth station designs provide for the use of solar power which tends to facilitate their use in many parts of the developing world.

The main drawback with satellite is one of start-up cost. Because of the high cost, it is much better utilized on a regional basis. Indeed, most of the existing satellite systems tend to be used for providing service on an international or regional basis.

With respect to data local-area networks (LANs) could be used to great advantage. PCs are particularly apt for developing countries and they are increasingly gaining a foothold in Africa. LANs could make possible the sharing of functions and extend the power of PCs. In particular, many organizations such as the ministries and various government institutions, which tend to be in close geographical proximity could be tied together using LANs to facilitate the movement of data needed for administration and planning. Communication between the different clusters could use the telephone network until such a point that a public data network was warranted. This would nicely complement the IT thrust.

Telecommunications have long been targeted as one area of investment by international development organizations such as the World Bank and the United Nations Development Program. Recently, however, there is increased interest in the U.S. private sector, especially, the telecommunications carriers. There is a realization that because of inadequate facilities in developing countries, revenue potential from the U.S. is curtailed. For example, no revenue results from incomplete calls even though equipment is still used. As a result, a new perspective is emerging along the lines that investing in telecommunications developing countries could significantly increase revenue-earning transactions in the U.S. Riding this new wave of thinking, it may be feasible to form consortia consisting of African and African-American entrepreneurs and the telecommunications carriers for telecommunications ventures.

4. Mode of Interaction

S&T could provide African countries with the tools for solving efficiently some of the difficult problems pertaining to food production and preservation, energy, health, sanitation and environmental control. In particular, the application of KITs makes possible the realization of small, modular, robust systems of modest cost which can be customized to the particular environment. For those countries with a reasonable level of competence, they provide unprecedented opportunities to provide social and economic solutions which would have been unthinkable otherwise.

The approach to utilizing S&T in Africa will differ from country to country. However, in all cases, the objective for their use should be the development of endogenous capability which will then act as a catalyst in the development process. This implies application for improved social and economic conditions. Their effective exploitation will require, among others, the following:

- The development of human resources, in the form of skills required to identify, select, adapt and effectively utilize and promote application, including formalized and on-the-job training with particular emphasis on IT and the importance of efficiently collecting, storing and processing information to provide the basis for decision making;
- The promotion of local R&D in the form of strengthening existing institutions and facilitating collaborative effort with other institutions in Africa, other developing countries as well as the industrialized countries;
- Fostering a better coupling between local R&D and local industry so as to effectively utilize the results while simultaneously providing a better focus for the R&D activities;
- The development of the industrial base through the promotion of local entrepreneurship, development of S&T business incubators and joint ventures in S&T with businesses and entrepreneurs in the industrialized countries.

The extent to which the countries will be able to take advantage of the vast potential offered by the S&T will depend on the capabilities which they possess. Nevertheless, almost all the countries will have to rely on outside partners for finance, technical and policy support. International cooperation in S&T offers an effective method of rapidly transferring applicable solutions to the problems in the developing countries. Such cooperation could range from the exchange of information and experiences to commercial arrangements for investments in S&T and technology transfers between countries. Close linkages could be fostered between universities, R&D institutions and business enterprises.

The U.S. will be one of the major external sources; and African-American participation in S&T could play a leading role. An effective partnering between Africans and African-Americans in S&T could help African countries organize themselves to utilize the technologies efficiently. The S&T experts and entrepreneurs could help to organize to respond effectively to the varying national needs. This would require that the prerequisite factors that are essential for the utilization of S&T are identified for different social, economic and legal environments. However, regardless of the characteristics of the environments in which the activities will take place, the level of knowledge and access to information, the R&D infrastructure and capabilities and the opportunities for transforming the results of the interactions to commercial ventures will be crucial.

Specific activities will include:

a. Influencing government policy to highlight the importance of S&T and to promote the application of IT as the underpinning technology for the effective utilization of S&T. This could be effected through the establishment of African and African-American multi-disciplinary group of experts in S&T to help integrate S&T into the framework of the local planning activity. These experts would be drawn from existing educational, professional and government institutions within the African countries and the U.S. The group would assist in the formulation of the country strategy, and advise on activities utilizing S&T. Among the functions in which this group could assist, would be the following:

   - The identification of the needs and problems of the country to which the S&T would provide advantageous solutions;
   - The assessment of scientific, technical and industrial resources of the country to establish the potential of the country in S&T;
   - Promotion of the utilization of R&D results in industry, facilitating the growth of the use of the S&T in industry and ensuring that effective utilization of S&T is at the core of the national agenda for industrial development;
   - Assessing the national training needs for effective utilization of S&T so as to advise decision makers;
   - Policies to atuact investments in S&T from U.S. businesses and mode of operation to maximize mutual satisfaction.

b. Promoting education in S&T at several levels. This will involve re-orienting training facilities to emphasize the acquisition of the necessary skills in S&T, especially, IT and the development of software. At the outset, the basic education infrastructure may have to be reviewed to emphasize the use of computers which form the basis for the application of S&T. Specialized programs will be necessary to train computer personnel – systems analysts, operators, programmers, maintenance personnel, etc. – as well as researchers. Also, a dynamic linkage will have to be established between universities, research institutions, industry and potential users of of the results of R&D activities. All of these requirements should be carefully projected to link education and training activities with demands of R&D, and finally, to opportunities in industry. A further linkage to the development of entrepreneurial and technological management capabilities in S&T will also be necessary as well as other support measures for the commercialization of results.

c. Encouraging and facilitating cooperative R&D and the exchange of information on S&T between African and African-American institutions. In this context, scholar exchange programs for students and faculty, and the establishment of sister relationships between the HCBUs and other African-American S&T institutions with counterparts in Africa should be actively promoted. This will form a cornerstone of the necessary education program that will be required to sustain the interaction. This will also help to bring a practical aspect to educational programs being offered in those institutions on the subject of people of African descent. Africans need to be better educated about African-Americans, and vice-versa.

d. Facilitating the commercialization of the R&D effort through the implementation of the results in local industry. This reinforces the role of R&D as an integral part of the development process while potentially creating a funding source for R&D from local industry. Such a symbiotic relationship is very healthy for the long-term success.

e. Getting the business and financial institutions in the U.S. interested in investing in S&T ventures in Africa. In particular, serious consideration should be given to the establishment of IT "factories" of all kinds: from basic data entry to software development.

It is important to attempt to integrate these interactions into the normal business activities if they are to survive in the long term. When they become part of the daily schedule with expectations and deliverables to satisfy performance, then the likelihood of success increases significantly. Making them a "hobby" jeopardizes the ability to generate the necessary commitment. Success with the integration strategy will also ensure that there is a firm business basis which, in turn, could over a period of time bring more resources. In the near term, entrepreneurial African-Americans will have to find various creative ways to persuade U.S. industry that interaction with Africa in S&T makes good business sense. Africans in S&T will have to provide them with the ammunition to make the case. Executed successfully, there will be satisfaction all around.

The case of Input Output Computer Services (IOCS)[19] is instructive. The Waltham, Mass.-based company engaged in computer manufacturing, maintenance and distribution, has had several contracts in Cameroon. Financed by the U.S. Export-Import Bank, it has been involved in automating all of the country's ministries, provision of software and hardware for the nation's high schools and lining up other U.S. manufacturers to supply such items as desks, cabinets and other furniture. Business in Cameroon has accounted for a significant percentage of total sales. IOCS has plans to expand to other parts of Africa and is looking forward to the collapse of the apartheid wall in South Africa, having passed up the opportunities offered by the collapse of the Berlin Wall.

5. Conclusion

This paper has argued that there is a need to nurture and vigorously promote business interactions between Africans and African-Americans in S&T since it creates a win/win situation for both sides, not just emotionally but economically. The urgent needs of Africa are in agriculture, effective utilization of mineral and other natural resources, energy, improved education and communications infrastructure. Against this background is a general perception in the U.S. business community of Africa being too risky for investment. While working to rectify that perspective, the application of knowledge-intensive sciences and technologies which require minimal capital investment or telecommunications which serves to complement business needs in the U.S. would appear to be a good entry strategy. It is important to promote partnerships among educational institutions, businesses and individual entrepreneurs as a way to ensure success. Also, for long-term success, any such interaction must be integrated into the normal business activities.

However, lest we forget the inescapable motivation, there is no alternative to making such an interaction a success because the issue, in the final analysis, is about how to liberate all people of African descent from the yoke of global non-recognition. Until one or more African countries gain respect as an economic force on a global scale, achievements by individual members of the African diaspora will continue to be denigrated.

TABLE 1: Social and Economics Conditions for African Countries

Country	Population Indicators				Economic Indicators		Education Indicators	
	Level (Millions)	Growth %	Infant Mortality (Per 1000)	Life Expectancy (Years)	GNP Per Capita (US $)	Agric. % in GDP	School Enrollment (%)	Literacy %
	1989	'65-'89	1988	1989	1989	1988	1987	1985
Algeria	24.5	3.1	72	65	2,340	13	76	50
Angola	9.7	2.9	135	45	610	-	47	41
Benin	4.6	2.8	115	51	380	43	63	26
Botswana	1.2	3.5	41	67	1600	4	100	71
Burkina Faso	8.8	2.2	137	48	310	33	32	13
Burundi	5.3	2.2	73	49	220	56	67	34
Cameroon	11.6	2.9	92	57	1,000	25	100	56
Cape Verde	0.4	2.5	-	66	281	14	68	47
Central African Rep.	3.0	3.0	102	51	390	43	66	40
Chad	5.5	2.1	130	46	190	41	51	25
Comorros Is.	0.46	3.7	-	57	460	36	56	-
Congo, People's Rep.	2.2	3.1	117	54	940	14	-	63
Cote d'Ivoire	11.7	4.0	95	53	790	44	-	43
Djibouti	0.4	3.5	-	48	-	4	-	-
Egypt	51.4	2.6	83	63	630	19	81	44
Equitorial Guinea	0.34	5.0	-	46	430	59	-	37
Ethiopia	48.9	2.7	131	48	120	41	34	-
Gabon	1.1	4.0	101	53	2960	11	100	62
Gambia	0.85	3.3	-	44	230	34	42	25
Ghana	14.4	2.5	88	54	390	49	71	60
Guinea	5.5	1.7	143	43	430	29	30	28
Guinea-Bissau	0.96	1.9	180	47	37	31		
Kenya	23.3	3.7	70	59	370	32	96	59
Lesotho	1.7	2.5	98	56	470	24	-	74
Liberia	2.5	3.1	130	50	-	-	35	35
Libya	4.4	4.2	80	62	5410	-	-	67
Madagascar	11.2	2.6	119	51	230	33	-	67
Malawi	8.2	3.1	149	47	180	36	66	41
Mali	8.2	2.2	168	48	270	48	23	17
Mauritania	2.0	2.5	125	46	490	38	52	-
Mauritius	1.1	1.5	22	67	1950	13	100	83
Morocco	24.6	2.5	73	61	900	16	52	33
Mozambique	15.4	2.6	139	49	80	65	68	38
Namibia	1.3	2.7	104	57	-	-	-	-
Niger	7.5	3.0	133	45	290	39	29	14
Nigeria	113.7	2.7	103	51	250	35	75	42

TABLE 1 (contd.): Social and Economics Conditions for African Countries

Country	Population Indicators				Economic Indicators		Education Indicators	
	Level (Millions)	Growth %	Infant Mortality (Per 1000)	Life Expectancy (Years)	GNP (US $)	% Agric.	School Enrollment (%)	Literacy %
	1989	'65-'89	1988	1989	1989	1988	1987	1985
Rwanda	6.9	3.3	120	49	320	38	67	47
Sao Tome & Principe	0.12	3.0	-	66	360	31	-	57
Senegal	7.2	2.9	78	48	650	22	60	28
Seychelles	0.07	0.9	-	70	4170	6	-	-
Sierra Leone	4.0	2.1	152	42	200	40	-	29
Somalia	6.1	2.7	130	48	170	65	14	12
South Africa	35.0	2.4	-	61	2,460	6	-	-
Sudan	24.4	3.0	106	42	470	31	49	-
Swaziland	0.76	3.4	-	56	900	23	82	68
Tanzania	25.6	3.4	104	54				
Togo	3.4	3.0	88	54	390	34	86	41
Tunisia	8.0	2.5	48	66	1,269	13	78	54
Uganda	16.8	2.9	101	49	250	67	70	57
Zaire	34.4	2.9	110	53	260	28	76	61
Zambia	7.8	3.2	78	54	390	19	97	76
Zimbabwe	9.6	3.6	-	63	640	13	98	74

- Not Available in Source

Sources: World Bank Atlas, 1990.
Social Indicators of Development, World Bank, 1990.

TABLE 2: Social and Economics Conditions for Developed Countries

Country	Population Indicators				Economic Indicators		Education Indicators	
	Level (Millions)	Growth %	Infant Mortality (Per 1000)	Life Expectancy (Years)	GNP (US $)	% Agric.	School Enrollment (%)	Literacy %
	1989	'65-'89	1988	1989	1989	1988	1987	1985
Belgium	9.9	0.0	-	75	16,390	2	99	>95
Canada	26.3	1.0	-	77	19,020	4	100	>95
France	56.2	0.4	-	77	17,830	4	100	>95
Germany, Fed. Rep.	61.3	-0.1	-	75	20,750	2	96	>95
Japan	123.0	0.6	-	79	23,730	3	99	>95
Netherlands	14.8	0.5	-	77	16,010	5	100	>95
Sweden	8.5	0.2	-	77	21,710	4	95	>95
Switzerland	6.5	0.3	-	77	30,270	-	100	>95
United Kingdom	57.3	0.2	-	76	14,570	2	93	>95
U.S.A.	248.2	1.0	-	76	21,100	2	100	>95

- Not Available in Source

Sources: World Bank Atlas, 1990.
Social Indicators of Development, World Bank, 1990.

TABLE 3: Social and Economics Conditions for Other Developing Countries

Country	Population Indicators				Economic Indicators		Education Indicators	
	Level (Millions)	Growth %	Infant Mortality (Per 1000)	Life Expectancy (Years)	GNP (US $)	% Agric.	School Enrollment (%)	Literacy %
	1989	'65-'89	1988	1989	1989	1988	1987	1985
Argentina	31.9	1.6	31	71	2,160	15	100	95
Bolivia	7.1	2.6	108	54	620	33	91	74
Brazil	147.3	2.4	62	66	2,540	9	100	78
Chile	13.0	1.7	20	72	1,770	-	100	94
Colombia	32.3	2.3	39	69	1,190	17	100	88
Costa Rica	2.7	2.5	18	75	1,780	18	98	94
Dominican Republic	7.0	2.6	63	67	790	18	100	77
Ecuador	10.3	2.9	62	66	1,020	15	100	88
El Salvador	5.1	2.2	57	63	1,070	14	79	77
Guatemala	8.9	2.8	57	63	910	26	77	55
Haiti	6.4	1.9	116	55	360	31	-	38
Honduras	5.0	3.4	68	65	900	21	100	59
Jamaica	2.4	1.4	11	73	1,260	6	100	-
Mexico	85.4	2.8	46	69	1,990	9	100	90
Nicaragua	3.7	3.2	60	64	500	28	99	-
Panama	2.4	2.4	22	72	1,760	10	100	88
Paraguay	4.2	3.0	41	67	1,030	30	100	88
Peru	21.1	2.6	86	62	1,010	8	99	85
Trinidad and Tobago	1.3	1.3	16	71	3,230	3	100	96
Uruguay	3.1	0.5	23	73	2,620	11	100	95
Venezuela	19.2	3.3	35	70	2,450	7	100	87

- Not Available in Source

Sources: World Bank Atlas, 1990.
Social Indicators of Development, World Bank, 1990.

TABLE 4: African-Americans in Selected Occupations

Occupation	Total Americans (Thousands)	African-American %
Computer Professionals	853	5.7
Dentists	170	4.3
Engineers	1,823	3.6
Physicians	548	4.3
Teachers, College	709	4.3

Source: Black Enterprise (June, 1990)

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Notes on the session "African and African–American Business Interactions in Science and Technology"

Robert H. Bragg
Lawrence Berkeley Laboratory

Dr. Boakye's talk was thoughtful and detailed. His introduction made a good case for the view that, apart from emotional ties, African–Americans have a vested self–interest in these interactions, because they will never be accorded the respect/status accorded to other minorities until African countries make the transformation from third world to developed country status. This requries economic growth based upon both internal and collaborative efforts which employ the leverage inherent in science and technology. Thus, one must assess strengths and choose activites that have a high probability of large economic benefits while still retaining a quasi–cottage industrial scale of capital investment.

Areas of focus identified were agriculture, minerals, energy, education and communications. Dr. Boakye in fact took the position that there is a strong positive correlation between number of telephones per capita in a country and its GNP! Special mention was made of information technology, biotechnology, new and renewable energy sources, remote sensing and telecommunications as areas where the capital investments necessary are small or are furnished by partners because it is in their interest to do so.

There was lively audience participation during the presentation and general agreement that the proposed modes of interaction were both reasonable and appropriate, e.g., joint ventures, partnerships, etc. However, some felt that the technical infrastructure implied in some of the proposed activities (which is part of the "noise" in developed countries) often does not exist in African countries.

A few personal comments: These ideas are important, but, more likely to bear fruit when addressed to engineers than to Bouchet'ers, and one cannot help but be alarmed at the comparison of efforts devoted to agriculture in Africa (typically 80% of the work force) to about 2–4% in developed countries. It suggests that the payoff in economic development will be maximized in the short run by concentrating on agriculture.

EDWARD BOUCHET CONFERENCE

ISSUES RELATED to the GRADUATE EDUCATION of AFRICAN STUDENTS

James C. Turner Jr.
Hampton University

and

Lester Rodney
Morehouse College

INTRODUCTION

Approximately half of the graduate mathematics students in the United States are nonresident foreigners. A small, yet increasing number of these students are African. Historically Black Colleges and Universities(HBCUs) can greatly benefit from the opportunity to educate African students; these students can contribute much to the strength and sophistication of our graduate programs. For example, the cause of science is advanced by these students and the insularity of HBCUs from Africa is reduced. In addition, they can return to help raise the scientific standards of their own countries as ambassadors of a HBCU education. It thus becomes important for us (the HBCU's) to look at issues related to how our graduate programs will be most beneficial to African graduate students, so that they can become the corner stones in the development of science and technology in Africa.

Issues

The fundamental importance of technology to the ongoing development of Africa's industrialization is well known in scientific circles. In light of America's technological pre-eminence, Africa and U.S. universities in general, and the Historically Black Colleges and Universities in particular should explore forming effective alliances which enhance the transfer of technology to Africa. Technology transfer as it is used here refers to the transfer of ideas, methods, and results from the scientific community in the U.S. to academic groups in Africa, which is later transferred to engineering and industrial groups. These alliances must ensure a healthy flow of technical talent, a flow required to feed an emerging technological society. Paramount to this flow is a pool of talented graduate students. For these alliances to be successful they must come to grips with the following issues affecting the graduate education of Africans in the United States:

* **What is Africa to do in order to ameliorate the consequences of its technological underdevelopment?**

  How can the shortage of technically trained workers be addressed?

  How can available workers be better utilized?

* **What changes are necessary to attract more students to the study of fields essential to the evolution of Africa's industrial development?**

  What and Who will stimulate students to study technical fields?

  How can the heavy dependence on technology transfer from the West be reduced?

* **How can Africa and the HBCUs prepare graduate students who are more valuable and effective in the nonacademic work place in Africa?**

  What changes would make graduate students more valuable to business and industry in Africa?

  What new educational programs could diversify the employment opportunities for scientists in Africa?

Reform in Graduate Education

Many of the issues raised earlier can be addressed by reforming graduate education in the United States. In fact, there are several reasons for suggesting changes in graduate education in the sciences. The following are reasons that are relevant to the graduate education of African students.

Reasons for Change:

* Although our graduate programs have done an excellent job in training researchers, they have been less successful in preparing students for positions in industry.

* There may be a mismatch between graduate programs and the existing job market in Africa.

* The emphasis on individual, independent research is over exaggerated. In fact in the real world or even in academic research, there is a great need for teamwork either within or across disciplines.

African and American Needs

The present demand for graduate training of African students at U.S. universities is driven by several factors:

* A broad technological development of Africa requires an increasing supply of graduate-level scientists.

* The annual enrollments in the area of the graduate education are on a steady decline in terms of numbers and quality.

* The global graduate-level output from universities is diminishing steadily in numbers and quality. For example, it is purported that in Nigeria at the doctoral level in mathematics the output is greatly diminished in the older universities and almost non-existent in most of the newer universities.

* At all levels the scarcity of qualified teachers has been a long standing problem which has now become more and more acute especially in the wake of the recent upsurge in student numbers.

Design of Graduate Programs that Compliments the Needs of African Students

In general there is a need to design programs that are sensitive to the needs of individual students and that recognize broad options for different career paths. These new designs should in addition take full advantage of existing and potential career opportunities in Africa.

The first step in designing a graduate program is to realistically assess your resources.

* What are the talents and interests of the faculty?

* What are the prospects for African links?

* Does your university possess strengths in other areas that could lead to interdisciplinary or joint programs with their counterparts in Africa?

* What financial support is available for prospective African students?

Graduate Program in Applied Mathematics at Hampton University

African Graduate Students: John Kwagyan (June 1991)
Peter Agbakpe (Sept. 1991)
Joseph Ametepe (Sept. 1991)

Funding: Stipend $1000/mo (12 months) + Tuition
Center for Nonlinear Analysis

Summer Programs:

University of Minnesota
Summer Institute on High Performance Computing

The Army High Performance Computing Research Center offered a Summer Institute on high performance computing. This program was intended for students who were interested in learning how to use high performance computing systems for scientific studies. Students had access to the AHPCRC Advanced Computing Systems (Cray-2, Cray X-MP, Connection Machine-2) and a state of the art visualization laboratory. An introductory course in the numerical analysis of high performance computing and training on the AHPCRC Advanced Systems was offered.

Conference Attended:

Inaugural Conference of the
Center for Nonlinear Analysis
"Perspectives in Nonlinear Analysis"

Workshop Attended:

MATHFEST 1991
Hampton University - Carnegie Mellon University
Hampton University

RESEARCH PROJECTS

Joseph Ametepe - "A TWO-STEP METHOD FOR A NONLINEAR HYPERBOLIC PROBLEM"

If a monochromatic strong laser beam is focused on a crystal, then after emerging, the light shows a measurable component of the second harmonic radiation. This phenomenon has been modeled by nonlinear forms of Maxwell's equations in the crystal. In this project, we investigate the numerical integration of this system. Recent studies discuss in detail the additive splitting of hyperbolic partial differential equations in order to solve such equations. In our study, we apply such a technique, which reduces the computational error by partially solving the equations analytically rather than totally numerically.

Peter Agbakpe - "STUDY OF AN IMPLICIT SCHEME FOR INTEGRATING MAXWELL'S EQUATIONS"

We investigate theoretically and numerically an implicit scheme for solving Maxwell's equations. Space discretization is obtained by the finite element method, while Newmark's scheme provides the time discretization. A semidiscretization error estimate will be derived and a study will be made of stability and consistency.

John Kwagyan - "Nonlinear Galerkin Methods: The Finite Elements Case"

In this project we will consider the approximation of evolution equations on large intervals of time when the space discretization is accomplished by finite elements. The algorithm that we study, called the nonlinear Galerkin method, stems from the theory of dynamical systems and amounts to some approximation of the attractor and the discrete space. This study includes a full analysis of stability and convergence of the method.

THE COOPERATIVE AGREEMENT

Between

THE NATIONAL MATHEMATICAL CENTRE
Abuja, Nigeria

And

THE CENTER FOR NONLINEAR ANALYSIS
HAMPTON UNIVERSITY
Hampton,Virginia

A cooperative agreement between the National Mathematical Centre and the Center for Nonlinear Analysis has recently been established. The first planned activity for this effort is a specialized workshop entitled

"Dynamical Systems, Turbulence and the Numerical Solution of the Navier-Stokes Equations".

This workshop will take place during the first and second weeks of August 1992. At that time, representatives from both centers will also explore other future activities.

Dynamical Systems, Turbulence and the Numerical Solution of the Navier-Stokes Equations

Our aim is to give a series of lectures describing new numerical algorithms that are well suited for the solution of the Navier-Stokes equations over large intervals of tome. The understanding and the numerical solution of the Navier-Stokes equations are major problems of fluid mechanics with important applications to engineering and fundamental research.

In recent years there has been considerable work on dynamical systems theory. this is due in part to the emergence of new ideas and new mathematical tools such as the work of S. Smale on attractors; the mechanism proposed by D. Ruelle and F. Takens for the explanation of turbulence; the popularization of fractal sets due to B. Mandelbrot and others after him. This attractor is the natural mathematical object describing the observed nonstationary flow, and its complicated structure is one of the cause of turbulent behavior. It is one of our aims in these lectures to combine the methods of dynamical systems and numerical evolutionary partial differential equations, in our attempt to make all the aspects of this new combined theory accessible to the nonspecialist.

For the Navier-Stokes Equations, the following questions are to be addressed:

Existence and Uniqueness of the Solution and Continuous Dependence on the Initial Data. These preliminary results are not even, but they are part of the definition of the dynamical system and most of the necessary tools are also need in other parts of the study. We thus include these results for the sake of completeness.

Existence of absorbing sets. These are sets which all the orbits corresponding to the different initial data eventually enter. The existence of such sets is a step in the proof of the existence of an attractor

Existence of a compact attractor. It will be shown that the equation possesses an attractor towards which all the orbits converge.

This attractor is called the *global* attractor since it describes all the possible dynamics that a given system can produce.

The answers from these questions will form the basis for the new algorithm, called the nonlinear Galerkin method, which will be used to model turbulence and approximate the global attractor.

Table of Contents

Working Meeting of the American Sited Members
Edward A. Bouchet - ICTP Institute
28 - 29 March 1992
Atlanta, Georgia

Session III: Issues Related to the Graduate Education of African Students in the United States
Chair: Anthony M. Johnson, AT&T Bell Laboratories
Main Speaker: James C. Turner Jr., Hampton University

DISCUSSION

(Selected comments and responses during and after talk.)

(Kwami Boakye) Traditional strengths of HBCU's in the area of agriculture should be exploited in the training of African students.

(James Turner) Graduate training in mathematics has traditionally been concentrated in "pure" mathematics and I see a need to push that in the direction of "applied" mathematics. For example, I don't see any need for a graduate degree in the area of Algebraic Topology in Africa. Why should a student get a masters degree at Hampton in "pure" mathematics, and then proceed to get a job in industry, where he/she will be immediately retrained to do something else!?

(Anthony Johnson) In your quest to modify the focus of the department from "pure" to "applied" mathematics, are their quantifiable results to report?
(James Turner) When I first arrived at Hampton, there were 2 graduate students in the mathematics department. Now we have 14 graduate students with a goal of reaching 20, which I believe is attributable to changing the emphasis more towards "applied" research problems.

(James Turner) British mathematics departments tend to emphasize "applied" research while American mathematics departments tend to emphasize "pure" research.

(Kwami Boakye) What is the correct balance of training, since not everyone will go on to a PhD?
(James Turner) An "applied" mathematics emphasis is probably more critical in obtaining employment at the master's degree level. A master's degree level person is more likely to go into an industrial or government laboratory where the problems will tend to be of an "applied" nature. For this reason a master's degree in "applied" research is probably more desirable than one in "pure" research.

(Shirley Jackson) Why not place applications in the course as opposed to "watering down" the "pure" mathematics?
(James Turner) Please don't misunderstand me, "pure" mathematics is absolutely essential in getting the fundamentals necessary to

attack "applied" problems. In fact the students have become impatient with the "pure" mathematics, pushing for an earlier transistion to "applied" problems.

(James Turner) Rather than attempt to cover all fields of mathematics we should concentrate on our strengths - focus! For example there is strong NASA support in Computational Fluid Dynamics and the Center for Nonlinear Analysis at Hampton couples with Physics and Materials Science.

(James Turner) Getting information about good African students has been difficult because of the poor information exchange between the US and Africa. Telephone and FAX communication has been difficult.
(Sekazi Mtingwa) The W. E. B. Du Bois Center in Accra, Ghana has a FAX machine that we may be able to utilize.

(James Turner) The African students that came into our program had a very strong mathematics background. They were so strong, that we immediately gave them computational problems -- something that in general we can't do with incoming African-American students. Three excellent African-American students took nearly two years to get to the same level of proficiency as the incoming African students. Nevertheless, these African-American students then proceeded to graduate at the top of their class.

(F. K. A. Allotey) I would like to send several Ghanan students to the upcoming conference in Nigeria. There is a general problem of finding support for West African students to attend this conference in Nigeria.

(Kwame Boakye) We should encourage the "twinning" of specific African universities with HBCU's to foster a long term relationship for mutual benefit.
(James Turner) "Twinning" works here in the US. Our "twin" is Ohio State University.
(Anthony Johnson) Does this "twinning" result in a truly symbiotic relationship between the HBCU and the majority institution?
(James Turner) Yes! Ohio State University has supported many of our students "without strings."

Anthony M. Johnson, PhD
Distinguished Member of Technical Staff
Photonic Circuits Research Department
AT&T Bell Laboratories
Room 4D-321
101 Crawfords Corner Road
Holmdel, NJ 07733-3030
Tel: 908-949-6764
FAX: 908-949-6010
email: 1314amj@homxc.att.com

Scientific Personnel and Equipment Exchanges Between African and African-American Physicists and Applied Mathematicians

Charles S. Brown, Ph.D.
AT&T Bell Laboratories
2000 Northeast Expressway
Norcross, Georgia 30038

I.) Introduction.

The topic of this paper is, "The Scientific Personnel and Equipment Exchange Programs of the Bouchet-International Center for Theoretical Physics (ITCP) Institute". Scientific personnel here refers to physical scientists such as physicists, applied mathematicians, engineers, etc. The exchange programs include: (1.) equipment transfers from the U.S.A. to Africa, (2.) student exchange for research facilitation and guidance from Africa to the U.S.A., (3.) visiting lecturers exchange from the U.S.A. to Africa, and (4.) visiting scholars exchange from Africa to the U.S.A. To date there have been no scientific equipment exchanges and only one scientific personnel exchange (namely, Prof. F.K.A. Allotey's current visit to Clark Atlanta University (CAU) and the University of Michigan (UM)). Also, the student research facilitations and guidance exchange program was discussed in the previous session. Therefore, in this paper only aspects of the exchange program between visiting scholars from Africa to the U.S.A. are discussed in detail. The other programs are mentioned and discussed only briefly.

In what follows, a discussion of the Bouchet-ITCP Institute objectives and the purpose of its programs is given. Then, brief discussions of the programs mentioned above are given. Next, the visiting scholar exchange program from Africa to the U.S.A. is discussed in more detail. Finally, the topic is summarized and concluded.

II.) Objective and Purpose of the Bouchet-ITCP Institute.

The objective of the Bouchet-ITCP Institute is to provide a vehicle for scientific collaboration between African and African-American physical scientists in order : (1.) to disseminate research results, (2.) to develop new ideas, insights, and activities on the current frontiers of science, and (3.) to enhance the state and impact of science and technology on the development of the African Continent. Implicit in these aims is the acknowledgment of the fact that both the African and the African-American (as well as other Africans in Diaspora) were historically discouraged and even prevented at times from direct professional participation in modern scientific and technical enterprises. Moreover, successful participation in our present "Information Age" world economy is increasingly dependent upon the level of science and high-technology in all sectors of a nation's economy and its society. The developed nations sustain their relative advanced standing by infusing a scientific and high-tech culture into their populations via their media, corporate, educational, and governmental institutions. On the other hand, African nations are among the poorest and most underdeveloped, scientifically and technically, in the world. While there is a small but increasing number of Ph.D. level physical scientists on the African continent today, they rarely are able to practice their science or develop into "world class" technical professionals in their home countries. The reasons for this were elaborated early in the papers given in sessions I and II of this conference and are not discussed here. While many seek and find scientific and technical employment abroad, there are a growing number who work at one of the over 200 Universities on the African Continent. Short of individual contacts abroad in the developed nations, many African physical scientists, especially those whose work involves the use of expensive computers and/or other technical equipment, maintain their professional standing and practice through interactions with ITCP. The programs of the Bouchet-ITCP Institute seek to offer an additional avenue for sustainable research opportunities for African physical scientists in the U.S.A. with their African-American counterparts. To this end, the programs were designed to enhance the level and duration of scientific and technical practice of both African and African-American participants. It is hope that the high quality of the research and training which results will encourage African governments to significantly increase their funding of scientific and technical research and education at home.

The programs of the Bouchet-ITCP Institute are, as mentioned in the Introduction: (1.) equipment transfer from the U.S.A. to Africa, (2.) student exchange for research facilitation and guidance from Africa to the U.S.A., (3.) visiting lecturers exchange from the U.S.A. to Africa, and (4.) visiting scholars exchange from Africa to the U.S.A. A brief description of the purpose of each program is given below.

i.) From Africa to America.

Student Research Facilitions and Guidance Program

Advanced graduate students matriculating at African Universities will use the research facilities of their African-American colleagues for their dissertation research. After the stay with their American co-mentor, the student should return to their home institution and complete the work on their dissertation.

ii.) From America to Africa.

Visiting Lecturers Program

The African-American physical scientists participating in this program will establish a continuing collaboration with the African host for a period of at least two or three years. This collaboration will include several visits to the African hosting institute, for lectures and discussions with the faculty and students.

Equipment Transfer Program

As part of the continuing relationship between the American physical scientists and the African recipient, responses to specific requests for equipment by the African host institute will be developed.

III.) Visiting Scholar Exchange from Africa to America Program.

The *visiting scholar program* from Africa to the U.S.A. is designed to extend visits of African physical scientists to American institutions for collaborating with African-American physical scientists. The purpose of the visits are to share their research endeavors and results, discuss current topical scientific issues, and give rise to mutually beneficial collaborations and extended relationships. Moreover, to insure the formation of extended relationships, it is important to include in-depth discussions of the history and culture of the African and the African-American, including their respective current state-of-affairs. This cultural education component should include trips and tours when possible to insure a thorough understanding of the common heritage of the African and the African-American and the differences and similarites of our respective current state-of-affairs. As mentioned earlier there has been only one visiting scholar in the Bouchet-ITCP Institute program . The experience gained from this initial visit is summarized in the following guidelines for arranging visits of African physical scientists to an American university.

IV.) Guidelines for Arranging Visits of an African Scholar to an American University.

- Certify a long-range research interest match through preliminary correspondences.
- Determine the compensation schedule desired by the African Visiting Scholar and the compensation schedules for foreign visiting scientist at your University, then negociate an agreeable compensation package.
- Identify funding sources such as:
  - Governmental research grant proposals (which could be written to include the collaboration and the visit).
  - Private foundation grant proposals.
  - Special university-wide and/or departmental visiting professor programs.
  - National laboratories special programs for Historically Black Colleges and Universities(HBCU).
- Obtain approval for the visit through your administration (department chair, dean, etc.).
- Make contact with your university's International Affairs Office to expedite the visa application process (this aspect can become lengthy and could delay or canceal the visit).
- Locate and arrange housing, accomodations, and local travel options for the visitor (priority must be placed on safety and convenience since some visitors are unfamiliar with American society).
- Certify insurance coverage for the visitor upon arrival and recommend a medical doctor and a dentist.
- Obtain an application for a social security number and file immediately upon the visitors arrival.
- Identify a convenient bank to serve the banking needs of the visitor.

V.) Guideines for a Productive Visit of an African Scholar to an American University.

In addition to the above guidelines, once the Visiting Scholar arrives, the following guidelines should be followed to insure a productive visit and collaboration.

* Arrange a work schedule for the Visiting Scholar which includes the teaching of one course.
* Establish a regular time to meet and identify research projects, discuss reseach results, write grant proposals, and discuss the agendas of the Bouchet-ITCP Institute.
* Establish a regular time to meet and discuss aspects of African and African-American history and culture.
* Write paper(s) on the research results and prepare oral presentation(s) to be delivered at both an American conference and the next Bouchet International Conference.
* Write research proposals which include the ongoing collaboration and future visits of the African American host to the African Scholar's home University.

VI.) Summmary and Conclusion.

As mentioned previously there are presently several student visiting American universities to facilitate and guide their dissertation research efforts, and there is presently one Visiting African Scholar in the U.S.A. The prospects for increacing the number of Visiting Scholars are great and need only more African-American host. The Bouchet-ITCP Institute has a list of potential African collabartors and their scientific areas of interest. All Council Members and associates of Bouchet-ITCP Institute are encouraged to contact interested colleagues and promot the Instutute's goals and programs.

Some **notes** on the session "Scientific Personnel and Equipment Exchanges"

Abdulalim Shabazz
Clark Atlanta University

The paper of Dr. Charles Brown speaks for itself. However, hereunder are some questions, answers and comments by conference participants.

1) African visitors need, indeed, to know something of the culture and language use of African-Americans. For example: An African visitor was very disturbed upon giving his name to an African-American and then hearing that American say, "That's a bad name!" However, he relaxed when the greeter explained to him that he meant his name is a good name.

2) In the minds of many Americans (both black and while) the Tarzan concept of Africa still lingers and in some instances is projected.

3) To aid in bringing African scholars into the USA, private foundations and government agencies can be helpful, e.g., the AT and T Foundation and the National Science Foundation. But, you must apply, yearly if necessary.

4) In bringing African scholars to the USA, safe housing should be considered and included in the support. This aid may also include furniture and food (meals) support. Safety is more important than distance to and from the campus.

5) Securing the proper or appropriate visa is very important and sufficient time must be taken to deal with this issue. Indeed, there is a need for a small group of people who are able to care for and look out for our African guests from overseas. That is, a particular African-American professor should be designated to handle the problems of visitors.

6) Exhange visits can be quite beneficial. But be very careful of the use of credit cards. Medical coverage in exchange relations should be considered and included in the financial package.

Don't lock your cars up in a garage during your stay overseas, for great deterioration can set in.

7) Retired professors (of the "right mind") should consider exchange visits to Africa. Also excess equipment and (little) used or unused books/journals should be sent there. Certainly this will help build linkages between Africa and America.

8) African–American scholars, educators and scientists should apply for Fulbright Fellowships to spend an academic year in Africa. They should first form linkages with African universities and develop collaborations with African scholars. Then apply for Fulbright's via these collaborations.

Fulbright fellowships may be for research, research with teaching or just teaching. There are regions in the world to which very few scholars apply to go. The research proposal should make sense relative to the country to be visited. Moreover, there should be some proof of interaction with the host country. Careful consideration of these facts and suggestions will help strengthen an application and make it competitive–leading to success.

Presentation at Conference

on

"Are We On The Threshold of A Pan-Africanist Cooperation in Science and Technology?"

Bouchet Institute

March 28, 1992

Atlanta, Georgia

by

Dr. Kofi B. Bota
Vice President for Research
Clark Atlanta University
223 James P. Brawley Drive, S.W.
Atlanta, Georgia 30314

When Ron Mickens called to ask if I would make a few remarks as the dinner speaker for this conference, I requested that he give me an hour or two to think about an appropriate theme or topic. In the hour before he called back, I thought about what the Bouchet Institute stood for. I have not participated in the programs of the Bouchet Institute so I could not honestly say that I knew about the Institute's vision, goals and objectives. But I knew about the conference held in Accra, Ghana two summers ago. I knew that members of this organization have spoken to me about, and yearned for, closer interactions with scientists and mathematicians in Africa. I have for sometime now, dreamed about holding a World Congress of Scientists and Mathematicians of African descent in Atlanta in the year 2000 as a sort of a 100th year commemoration of the Pan African Congress held in Germany in 1900 which was attended by DuBois and others.

The 1900 Congress was a political congress, and no doubt an appropriate one. Indeed DuBois' prophecy that the problem of the 20th Century was the color line has been more than borne out, and as we close out the 20th Century, it is perhaps fitting that we would end it with the burial of apartheid in South Africa .

The title of my talk this evening, "Are we on the threshold of a Pan Africanist cooperation in Science and Technology" was chosen to spur a new paradigm, a new thinking for Africa and its descendants everywhere. Are the peoples of Africa and people of African descent on the verge of becoming marginalized in the new world order? Or are persons such as yourselves going to step up to the altar of leadership and provide some of the answers to the many problems that plague communities of African descent everywhere. Surely, it is easy to give up in these dark ages of hopelessness and homelessness, of disease and starvation, of violence and pathology, whether it be in New York, Atlanta, Lagos, Lusaka or Johannesburg. While the putative end of the cold war may mean that African, nations and people of African descent are no longer pawns in the East-West ideological conflict, it may also bring neglect and marginalization in the new global economic and political order. However, I understand there is a Chinese proverb that says that in every problem there is an opportunity. So I see opportunities for new attitudes, new resolutions, new efforts to address the deprivation and squalor in communities of African descent. The work of the Bouchet Institute in the past few years and the fact that you are meeting here in Atlanta today indicate that already there are stirrings in our own communities to address our own problems. Surely, no other ethnic or racial group has yielded or will ever yield its future into the hands of other races.

I submit that it is our own institutions that will lead us from the wilderness of despair to the promised land that Martin Luther King Jr., spoke and dreamed about. This promised land will not be built and realized until our institutions and leaders step up the challenges of the moment.

How can we achieve this?

- o This can be achieved if each of us in our own individual lives seeks to make a difference and to lighten the burdens of others.

- o This can be achieved if each of us, having benefitted from the toils and sacrifices of others, seek to be a role model and a mentor to a child in our community, who is without a home or a father, or a book or a bicycle.
- o This can be achieved when the presidents and vice presidents and deans and professors and students in the Atlanta University Center, or other Historically Black Colleges and Universities do not wait for a Jimmy Carter, influential as he may be, to launch an Atlanta or similar projects before they realize that the answers to the problems and ills that plague communities of African descent lie in our hands.
- o This can be achieved when African American physicists and chemists and biologists seek to collaborate with their counterparts in Africa and the Caribbean, as some members of the Bouchet Institute are doing.
- o This can be achieved when members of the Bouchet Institute exert their influence and support the Walter Masseys and Lou Sullivans more resources to communities of their heritage.

People like me are waiting for scientists of African descent to make a life-long commitment to solve problems such as sickle-cell anemia, river blindness, malaria and so-called ethnic diseases that afflict our communities disproportionately. Physicists and chemists are joining forces with molecular biologists and geneticists in the brave new world of the new biology. The barriers separating biology, chemistry, physics and engineering are being breached by a new generation of well-trained scientists and engineers. Studies of three-dimensional structure of biomolecules at the atomic level;

rapid advances in developmental biology, plant biology and agriculture; in understanding of the cell; in understanding the ways in which nerve cells of the brain direct behavior and how the immune system deals with the challenge presented by pathogenic microbes, malignant cells, and foreign macromolecules, have all been made possible by interdisciplinary and multidisciplinary cooperation.

If scientists and mathematicians of African descent are to play their role in these new frontiers of science and technology, then we must help build our own institutions be they in Africa, the Caribbean, or the United States through cooperation. And when we do, we must insist that these institutions serve the needs of our communities. In this connection, I would like to quote an excerpt from an essay written by W.E.B. DuBois in 1933 entitled "The Field and Function of the Negro College". "If this is true, then no matter how much we may dislike the statement, the American Negro problem is and must be the center of the Negro university. It has got to be. You are teaching Negroes. There is no use pretending that you are teaching Chinese or that you are teaching white Americans or that you are teaching citizens of the world. In other words, the Spanish university is founded and ground in Spain, just as surely as a French university is French. There are some people who have difficulty in apprehending this very clear truth. They assume, for instance, that the French university is in a singular sense universal, and is based on a comprehension and inclusion of all mankind and of their problems. But it is not, and the assumption that it is arises simply because so much of French culture has been built into universal civilization. A French university is founded in France; it uses the French language and assumes a knowledge of French history. The present problems of the French people are its major problems and it becomes universal only so far as other peoples of the world comprehend and are at one with France in its mighty and beautiful history. In the same way, a Negro university in the United States of America begins with Negroes. It uses that variety of the English idiom which they understand; and above all, it is founded, or it should be founded on knowledge of the history of their people in Africa and in the United States, and their present condition."

At the dawn of the 21st Century, I ask you as members of the Bouchet Institute to show and lead the way to make real the message of DuBois embodied in this excerpt. Surely, if DuBois were alive today, he would ask what is our sense of commitment to the legacy of our forefathers, who in times worse than these freed themselves from bondage and ignorance and despair. We must work together to build the Historically Black Colleges and Universities and higher education institutions in Africa to become citadels of learning; to become agents of change; to become institutions that catalyze business and industry development in high technology in communities of African descent in the U.S., the Caribbean, and Africa. I see us working together to make Howard, Hampton, North Carolina A&T, Clark Atlanta, Florida A&M to become first-class universities not only to produce tomorrow's leaders for the African American community; but to also serve as the gateway to the United States, and provide the supporting environment, for students and faculty from Africa and the Caribbean to study and conduct research and pursue scholarship.

Funding the Bouchet Institute's Programs: A Brief Report from the Chairman

Joseph A. Johnson III
Department of Physics
Florida A&M University
Tallahassee, FL

Introduction

In the early 1980's, Prof. Abdus Salam, Director of the International Centre for Theoretical Physics (ICTP), approached Prof. J. A. Johnson III of the City College of New York (CCNY) and expressed an interest in the feasibility of some kind of interaction between African-American physicists and African physicists and applied mathematicians. This was on the occasion of Prof. Salam's participation in the commencement exercises at The City College of New York during which Prof. Salam received the D.Sci degree *hon. causa*. Subsequently, Prof. Johnson and Prof. Bennie Ward established the Black American Friends of ICTP as a device for facilitating some kind of initiation of the interaction which Prof. Salam was encouraging. Approximately 20 African American physicists agreed to participate in this enterprise, with Prof. Johnson's encouragement; the group agreed to convene along with Prof. Jean P. Ezin of the University of Benin the First Edward Bouchet International Conference on Physics and High Technology.

The Conference was held in Trieste during June 88 and had roughly 60 attendees. It was during the conference that a consensus was reached on the issues and appropriate motivation for a continuing organization,- The Edward Bouchet-ICTP Institute. This was followed by the appointment of the first Advisory Council for the Bouchet Institute and the organization of the Second International Conference on Physics and Technology. In addition, the Office of USA Programs was opened with Dr. Lynette E. Johnson as Director and the Office of Africa Programs was opened with Prof. Francis Allotey as Director. Other details concerning the Conferences are available in the published Proceedings.

The general scope of USA funding and of current activities is indicated in Tables I and II. Many actual interactions and collaborations have begun.

This is the background for the Atlanta Bouchet Conference which has, as a general purpose, the calibration and focusing of the overall efforts.

The Nature of the Bouchet Institute

First of all, the Bouchet Institute is not an organization with members. There are no dues and no qualifications for candidacy. It does not exist, therefore, as a target for general support or general solicitation.

Rather, the Bouchet Institute is a program of activities endorsed by the ICTP, implemented by an Advisory Council appointed by the Director of the ICTP. In this form, it is a creature of ICTP and exists at the pleasure of the ICTP Director. The Advisory Council members have been reappointed by the Director of ICTP to serve through 1992.

The program of activities is now well defined as follows:

1. A set of international conferences. The first two have already been held. A third conference is now being planned which will focus on the results from the collaborations between African and African American physicists and applied mathematicians.
2. Library donations. The need for current issues of the major journals in physics libraries on the continent is to be matched with prospective sources of these journals and funds for their shipment and distribution.
3. Equipment donations with follow-up. Functioning research grade hardware is to be made available as a part of continuing relationships which, due to the intended persistence of the interactions, will bring a longevity, durability and flexibility to the enterprise which is organized around the equipment.
4. Exchange of visits and associated scientific collaborations. Cooperative research investigations are to be encouraged. Full term sabbaticals are to be encouraged, going in both directions. Short courses are also to be encouraged with African Americans bringing targeted subject matter to the African host, and the same process for the prospective American host in reverse. Shorter visits are also to be encouraged especially in those cases where major facilities can be used in a way where the analyses have portability. These interactions are to be purposeful with the quantity and quality of scientific publications

resulting being one of the chief indicators of the merit of the relationships.

5. The mentoring by African American physicists of Ph.D. research for degrees at African Universities. This includes research which might be done at industrial laboratories as well as universities and research which might be done with colleagues of the host African American physicist or applied mathematician. The routine matriculation of African students at American universities is not included as a program element; nonetheless, as appropriate, facilitations of such study are not ruled out as an endorsed activity.

Generally stated, the relationship between the Institute and participating African American physicists and applied mathematicians is clear. Specifically, the activities and interest of the community of African American physicists and applied mathematicians on matters of the sort which form the Institute's programs stand on their own merit. In addition, and very importantly, these activities and interests can be used to justify the existence of the Institute and its role as a target, when appropriate and necessary, for funds.

Funding

With regard to implementation of these programs, the Institute assumes full responsibility for its conferences. However, this has traditionally meant the members of the advisory council and other supportive participants have had to raise funds through proposals and direct solicitations. It is also true that ICTP, as the parent entity, has always contributed very substantially to the conference support funds.

As for the other program elements, the Institute encourages and, where possible, helps to facilitate donations of equipment and library materials. The American Association for the Advancement of Science and the Third World Academy of Sciences are prospective major components in the library and equipment distributions. In any event, the donation of equipment is expected to be associated with a substantial personal and program commitment on behalf of the donor so that the equipment can be maintained and can play an important part in the evolution of a scientific collaboration.

The Institute also encourages and, where possible, helps to facilitate the scientific collaborations and the education of African physicists and applied mathematicians. However, the African American particpants must persue funds on their own initiative. The Institute has no money for direct support of science. The important details in these activities are managed directly by the investigators involved. This includes the determination of overlapping interests, of compatible personalities, immigration requirements, housing, and the nature of the interactions as the African colleague returns to the home African country.

In the past, the conferences have been funded by federal agencies and private foundations. The other activities have been funded by federal agencies and by private businesses. The individual African Americans have raised this money. Tables I and II summarize the present funding modalities. In the future, funding will probably come from the same combination of federal and private sources, with the same general breakdown insofar as conferences, other activities, and the requirement of direct action by African Americans for financial support.

Conclusion

The primary issue now, it seems, is fundability. Simply stated, participants in Bouchet Institute activities need to increase in number and in level of productivity. This is required in order to provide an adequate number of prospective papers for a Third Bouchet Conference now planned for 1994.

In addition, a consistent level of documentation is required in order to have a potential for successful encounters with funding sources. Specifically, documentation is needed on:

a. Publications (all stages)

b. Presentations

c. Names of all collaborators

d. Titles (or subjects) of research

With this information and a continuing increase in the quality and vigor of our collaborative enterprises, the options for future sources, as outlined above, can be easily pursued.

USA Funding History: Conferences

Date	Source	Project	Project Director
1988	National Science Foundation	First Int'l Bouchet Conf.	Lynette Johnson
1990	National Science Foundation	Second Int'l Bouchet Conf.	Lynette Johnson
1990	Rockefeller Foundation	Second Int'l Bouchet Conf.	Joseph Johnson
1990	MacArthur Foundation	Second Int'l Bouchet Conf.	Joseph Johnson
1991	Office of Naval Research	Atlanta Conf. on Bouchet Activities	Ronald Mickens

Table I

Summay of Current Activities

Principal	Institution	Activity	Overall USA Funding Source(s)
Bragg, Robert	UC, Berk	Nigerian Collaborations	
Brown, Charles	AT&T Bell	Host, Francis Allotey	CAU
		Participant, Senegal Conference	AT&T
		Lecturer, Ghanian Institutions	
Johnson, Anthony	AT&T Bell	Participant and Lecuterer, Senegal Conference	AT&T
Johnson, Joseph	Florida A&M	Ph.D. Mentor, Student from Benin	NASA, NSF
		Examiner Designé,University of Ghana	
Johnson, Lynette	Florida A&M	Facilitator, Library Donations	
		Facilitator, Various African/African-Amer. Connections	
Jones, Herb	Florida A&M	Nigerian Collaboration	
MacGruder, Charles	Fisk	Mentor, Nigerian Student	
		Nigerian Collaboration	
McGuire, Stephen	Cornell	Member, Atomic Energy Commision of Ghana	
		Various African Facilitations	
Mickens, Ronald	Clark Atlanta U	Ph.D. Mentor, Student from Benin	CAU
		Host, Francis Allotey	
Mtingwa, Sekazi	North Carolina A&T	Various Lectures and Facilitations, Ghana	
Neal, Homer	Univ. of Mich.	Host, Francis Allotey	UMich
Reed, Kennedy	LLNLab	Various African Facilitations	
Slaughter, Milton	Univ. NO	Mentor, Ghanian Student	UNO
St. Mary, Donald	Univ. Mass	Lecture Organizer, Nigeria	
Stith, James	US Mil. Academy	Participant and Lecturer, African Conference	
Turner, James	Hampton Univ	Mentor, Three Nigerian Students	Hampton
		Lecture Organizer, Nigeria	
Winful, Herbert	Univ of Mich.	Host, Francis Allotey	UMichigan

Table II

Notes on the session "Funding the Bouchet–ICTP Institute"

Charles McGruder
Fisk University

There was much discussion by participants both during and after Johnson's presentation. The following is a brief summary of selected comments, suggestions, issues, etc.

* The activites of the Bouchet–ICTP must be documented. Examples: number of African student and scholar exchanges to the United States; research collaborations; presentations at professional meetings; research and related publications; equipment/book transfers to African universities; etc.

* Pressure must be exerted on the National Science Foundation to put funds into its Sub–Sahara Program.

* A major function that African–American scientists can do is to take on the task of consulting with African graduate students and help to place them in education/research positions in North American universities and national laboratories.

* Bouchet–ICTP conferences should have an organizing committee in the host country. This committee should have strong ties to both the local and national governments, and be a strong participant in all planning activites. This group can also issue official letters of invitation.

* Future trips to Bouchet–ICTP conferences will, in general, require Africa–American scientists to make their own travel arrangements, i.e., funding will come from their individual grants, universities, etc., rather than a group proposal for travel.

* Long term planning is needed for all Bouchet–ICTP activities, especially those related to meetings, graduate education of African students, and research collaborations.

* Are there international foundations that would be willing to help in supporting the various programs of the Bouchet–ICTP Institute? Who should be contacted and where would the funds be "housed"?

RESEARCH OPPORTUNITIES
IN THE
UNITED STATES

Invited Talk Presented at the Working Meeting
of the
Bouchet Council

Atlanta, Georgia
March 29, 1992

Sekazi K. Mtingwa
Department of Physics
North Carolina A&T State University
Greensboro, North Carolina 27411

I. Places to Do Research

There are three primary places for doing scientific and technological research in the United States: private corporations, national laboratories, and universities and colleges.

A. Private Corporations

Private corporations are not very promising for basic scientific research, even for domestic scientists. The closest that one generally comes to basic scientific research in the private sector is at AT&T Bell Laboratories. But even there, the recent push has been to support only those research programs which readily contribute to the profit-making part of the company's operations. Most industrial funding is geared toward nonproprietary knowledge. Fields with the most relevance to industry are computer science, metallurgy, materials science, chemistry, biology, etc.

B. National Laboratories

The national laboratories host a rich variety of basic research programs. In nondefense related research, there are many opportunities for African scientific visitors to collaborate on research projects. However, these must be arranged on a one on one basis with individual researchers at the laboratories.

What are some of the advantages and disadvantages to the government of having national laboratories?

Advantages of National Laboratories[1]

1. They can maintain a particular research effort over one or more decades.

2. They can easily incorporate a multidisciplinary approach to problems.

3. They can more often fund "risky" research since national laboratories can absorb a setback without jeopardizing graduate students or young faculty.

4. Project managers from the Federal funding agencies can easily maintain their involvement in the research projects.

5. Research can be put on a fast track when results are needed on a timetable.

6. They can often perform research at a reduced cost.

[1]1. U.S. Congress, Office of Technology Assessment, *Federally Funded Research: Decisions for a Decade,* OTA-SET-490 (Washington, DC: U.S. Government Printing Office, May 1991), p. 119.

Disadvantages of National Laboratories[2]

1. Higher salaries in academia and industry for the more gifted researchers have limited the quantity and quality of research at the national laboratories.

2. They often do not support graduate students.

3. The national laboratories are large organizations built with a mission (or set of missions) in mind; once the mission has been achieved or abandoned, the laboratory must then find a new mission or face downsizing or phaseout.

C. Universities

Academia offers by far the most varied assortment of leading-edge research possibilities. The typical research team in the university consists of the following:

1. Principal Investigator (most often a faculty member) who has the major responsibility for the research project
2. Other Faculty
3. 1-2 Postdoctoral Scientists
4. 1-5 Graduate Students
5. Several Undergraduate Students
6. Technicians

[2]Ibid., p. 120.

7. Additional Nonfaculty Ph.D. Researchers

The Additional Nonfaculty Ph.D. Researcher category certainly is one which should be used as often as possible to involve African scientists and engineers in U.S. research programs.

What are the advantages and disadvantages of university research from the point of view of Federal funding agencies?

Advantages of Universities[3]

1. They offer competition on the "open market" for the best research teams for a particular problem.

2. The researchers are paid competitively and can be solicited for single projects.

3. The researchers are the very best scientists and engineers and enjoy access to state-of-the-art equipment.

Disadvantages of Universities[4]

1. The university research structure, with a professor and his/her graduate students, often operates too slowly.

2. The government funding agencies reserve the right to

[3]Ibid., p. 120.

[4]Ibid., p. 120.

terminate a research project at any point, which could be disastrous for a professor and especially for graduate students.

II. Statistics on Research Funding

A. Federally Funded Research by Agencies in 1990 (1982 Dollars)[5]

1. HHS[6]	$ 6 Billion
2. DOD	2.5
3. NASA	2.5
4. DOE	2.0
5. NSF	1.5
6. USDA	1.0

B. Federally Funded Research by Discipline in 1990 (1990 Dollars)[7]

1. Life Sciences	$8.9 Billion
2. Engineering	4.4
3. Physical Sciences	4.0
4. Environmental	2.1
5. Math/Computer Science	0.7
6. Social Sciences	0.6

[5] Ibid., p. 8.

[6] HHS=U.S. Department of Health and Human Services; DOD= U.S. Department of Defense; NASA=National Aeronautics and Space Administration; DOE=U.S. Department of Energy; NSF= National Science Foundation; USDA=U.S. Department of Agriculture.

[7] Ibid., p. 7.

C. Federally Funded Research by Performer in 1990 (1990 Dollars)[8]

1. Industry	$3 Billion
2. National Laboratories	6
3. Universities & Colleges	8

D. Federally Funded Basic Research by Performer in 1990 (1990 Dollars)[9]

1. National Laboratories	$2 Billion
2. Universities & Colleges	5

E. Research and Development (R&D) as a Percentage of the Total Federal Estimated Budget for Fiscal Year 1991[10]

1. R&D	4.7%
2. Basic Research	0.9

F. 10 universities receive 25% of the Federal Research Funding while 30 universities account for 50%.[11]

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[8] Ibid., p. 8.

[9] Ibid., p. 8.

[10] Ibid., p. 11.

[11] Ibid., pp. 9-10.

G. General Sponsorship of Funded Research[12]

1. Federal Government	47%
2. Industry	42
3. Universities & Colleges (Includes state and local funds)	7
4. Nonprofit institutions & others	4

H. General Sponsorship of Funded Basic Research[13]

1. Federal Government	62%
2. Industry	21
3. Universities & Colleges (Includes state and local funds)	12
4. Nonprofit Institutions & Others	5

I. Federal Support for Computer Science[14]

The computer might be called an "enabling technology" since it is a tool for advancing research across a broad spectrum of disciplines. Since 1976, the Federal Government's support for academic computer science has grown faster than for any other scientific discipline. Between fiscal years 1976 and 1989, Federal obligations for computer science research grew from $89 million to $487 million. And Federal funding for academic computer science research rose between 1976 and 1989 from over $27 million to $235

[12] Ibid., p. 52.

[13] Ibid., p. 54.

[14] Ibid., p. 152-153.

million in current dollars. Federal agencies' long-term funding of computer science and engineering research, particularly in the universities, has been a primary factor in the emergence and maturation of computer science as a distinctive discipline.

J. Personnel Expenditures

1. For the past three decades, personnel expenditures have accounted for about 45% of the total costs of academic research charged to the Federal Government, consistently the largest share of the budget.[15]

2. In 1988 dollars, the average salary and benefits for a full-time equivalent principal investigator in the natural sciences and engineering increased from $59,000 in 1981 to $70,000 in 1988.[16]

K. Equipment Expenditures

1. The mean purchase price per system for all in-use equipment in 1985-1986 was $36,800.[17]

2. The turnover of research equipment is high; 2/5 of the systems in research use in 1985-1986 had been acquired in the 3-year period prior.[18]

[15]Ibid., p. 176.
[16]Ibid., p. 188.
[17]Ibid., p. 179.
[18]Ibid., p. 178.

L. Other Expenditures

1. The proportion of Federal monies out of all monies spent on academic facilities has never topped 1/3. Now it is less than 10%.[19]

2. By 1988, the Federally reimbursed indirect costs were about 25% of the academic R&D funding.[20]

III. Megaprojects

Many state-of-the-art research projects require huge expenditures of money and other resources as compared to other investments in the same or similar fields, hence the name megaprojects. These huge expenditures are necessary if we are obtain knowledge unattainable by any other means. Some examples are the following:[21]

A. Hubble Space Telescope	Greater than $2 Billion
B. SSC	Greater than $10 Billion
C. APS	$ 0.5
D. CEBAF	
E. FNAL	

[19] Ibid., p. 192.

[20] Ibid., p.193

[21] Ibid., pp. 156-163; SSC=Superconducting Super Collider (near Dallas, Texas), APS=Advanced Photon Source (near Chicago, Illinois), CEBAF=Continuous Electron Beam Accelerator Facility (Newport News, Virginia), FNAL=Fermi National Accelerator Laboratory (near Chicago, Illinois).

There are many opportunities for African scientists to become involved in megaproject endeavors. Many megaprojects operate as user facilities, such as the accelerator centers at FNAL and CEBAF. In these cases, researchers from around the world build small components of their experiments in their individual laboratories and then go to the locations of the magaprojects to install these components and run their experiments. Thus, it is possible for African scientists to study the structure of the proton without having to build a costly proton accelerator.

IV. Argonne National Laboratory (ANL)

(Located in Argonne, Illinois, near Chicago)

For most of history, humans have used natural materials, such as stone, wood, gold, iron, and animal tissue. Then they learned to smelt metals and make glass. But nowadays, science and technology have advanced to the point that once the need for a particular set of material properties is identified, scientists and engineers can go to the laboratory and construct the material atom by atom. The United States leads in the R&D of advanced materials while Japan leads in their commercialization. Some examples of these advanced materials are integrated circuits, optical fibers, reinforced plastics, and ceramics. In the 1980's, advanced materials have provided many of the new technologies, including:

1. Fax Machines
2. Personal Computers and Workstations
3. Wireless Telephones for Automobiles and Other Uses
4. Video Cassette Recorders
5. Human Body Parts

The race to develop and commercialize new materials has led to the emergence of materials science as perhaps the hottest R&D field at the present time. It is composed of the following four basic components:

1. Atomic structure and composition
2. Properties of materials
3. Performance of materials
4. Synthesis and Processing

Materials science combines metallurgy, ceramics, solid state physics, polymer science, chemistry, electrical and mechanical engineering, and some other areas. It was necessary to combine these fields in order to construct materials starting from their atomic constituents and achieving their desired functional material properties.

A major scientific tool to bolster these efforts in materials science will be Argonne National Laboratory's Advanced Photon Source (APS). The APS, which is presently under construction, is a circular accelerator 2/3 mile in circumference which will accelerate positrons (positively charged electrons) up to energies of 7 GeV (billion electron volts) and then pass the positron beams through magnetic fields which will wiggle the beams and cause them to give off synchrotron radiation (light) at wavelengths corresponding to X-rays.

The first generation synchrotron light sources were electron accelerators from which X-rays were produced parasitically as other studies were in progress. That is, those electron accelerators were built for other reasons, but the scientists learned that they could extract X-rays from them to probe the properties of materials. Second generation synchrotron light sources were built expressly to provide X-rays for materials science research. The 7 GeV APS is a third generation synchrotron light source which will provide X-ray beams 10,000 times more brilliant than those from previous such devices. Besides creating some 1,500 jobs during construction, it will add about 300 full-time scientific and technical jobs to Argonne National Laboratory. When completed in the mid 1990's, it will attract thousands of users from industry, academia, and national laboratories to study atomic and molecular structure of materials in greater detail than previously possible. At any one time, more than 300 scientists and engineers will perform as many as 100 different experiments. The APS will allow scientists to study crystals as small as 1 micron (0.00004 inch) for the first time. Among others, it will explore the following areas:[22]

Chemistry

The APS could create a whole new field of chemical analysis by permitting studies of intermediate products formed during fast-

[22]"Argonne News," published by the Office of Public Affairs, Argonne National Laboratory, Argonne, Illinois, March, 1988.

acting reactions taking place in 40 billionths of a second.

Petroleum

The APS will be capable of determining the detailed structure of materials which act as catalysts during oil refining. The crystals of these materials are 200 times smaller than can be studied at existing X-ray sources.

Semiconductors

It could lead to better ways of growing semiconductor crystals for electronics applications.

Enzymes

APS studies of the structures of proteins and enzymes (catalysts which control metabolism) could lead to designer drugs to aid disorders involving digestion, blood clotting, blood pressure, etc. Also, biologists will be able to take 3-dimensional photos of enzyme reactions that take place in thousandths of a second.

Polymers

These are long, complex molecules with many practical applications. The APS will aid the national effort to develop lightweight, high strength materials for aerospace and cther applications by allowing more detailed studies of the structure of polymers.

Steel

Stronger steels for construction could result from studies of the structural changes that take place during the heat treatments which strengthen steel.

Coal

Cheaper, cleaner ways to burn coal could result since scientists for the first time will actually observe chemical reactions that take place while coal burns.

ANL is also heavily involved in computer science research. The new generation of parallel processing computers appears to be the most promising way to meet our future computational requirements. Parallel processors differ from computers of the past in that they perform several programming steps simultaneously. Understandably, they are more difficult to use effectively than sequential computers of the past. As such, there is an immediate need to analyze various languages for programming multiprocessor systems. New algorithms and mathematical techniques are needed which take maximum advantage of the unique properties of parallel computers. Also, programs written for one machine are not easily run on another. Computer scientists at ANL are developing various kinds of software which can be run on a variety of different parallel computers with a minimum of rewriting as you go from one machine to another.

Another research area being pursued at ANL is high temperature superconductivity. Superconductivity is the frictionless flow of electrons through a material. It was discovered in 1911 when a Dutch scientist, Kamerlingh Onnes, found that certain metals lost all resistance to electricity when cooled to near absolute zero (-459 degrees Fahrenheit). The old niobium alloy materials became superconducting by cooling with 4 degree Kelvin helium. But the new class of ceramic materials were discovered in the 1980's to be superconducting at greater than 90 degrees K so that they can be cooled with liquid nitrogen. Since the air we breathe is 78% nitrogen and 21% oxygen, nitrogen is plentiful enough and easily processed so that liquid nitrogen is 50 times less expensive than liquid helium. This fact alone gives a major advantage to the new class of ceramic superconductors.

The new high temperature superconductors might one day be used in energy generation and transmission, more efficient motors than we presently have, high-field electromagnets, superfast computers, medical diagnostics, levitated trains, and many other applications. They could cut the cost of electrical generators by up to 60% and reduce operating expenses of large electrical motors by 25%.

When electricity comes into our homes from electric power generating stations, much of the energy carried by the electrons is lost via heat friction caused by the collisions of the electrons with the wire in which they are traveling and with each other. Superconducting transmission lines would eliminate this problem and therefore allow electricity to be carried long distances much more economically. Thus, we could make greater use of site-specific sources, such as geothermal, hydroelectric and solar energy, that are located far from population centers. Moreover, nuclear and coal-fired power plants could be built further away from high population areas.

Magnetically levitated (maglev) trains may be the most frequently mentioned application of the new superconductors. The major advantage here is the reduced maintenance. For example, the steel-wheel Japanese bullet trains, going 120 miles/hour, must have their tracks realigned each night. The maglev trains would make this realignment unnecessary.

The two major problems confronted by researchers studying the new superconductors are that they are too brittle for many applications and they cannot support current densities large enough for most practical uses.

V. Continuous Electron Beam Accelerator Facility (CEBAF)[23]

(Located in Newport News, Virginia)

CEBAF is an intermediate energy electron accelerator which should be completed in the mid 1990's. In it, electrons are accelerated up to energies in the range 0.4 to 4 GeV. By colliding these electrons with target materials, scientists hope to study nuclear structure, the quark substructure of protons and neutrons, and the strong, electromagnetic, and weak forces in ways never before achieved.

VI. Fermi National Accelerator Laboratory (FNAL)[24]

(Located in Batavia, Illinois, near Chicago)

This is the world's most powerful proton accelerator. It accelerates protons and antiprotons up to 1 trillion electron volts (TeV) of energy in a circular accelerator 4 miles in circumference. Subsequently, the two counter-rotating beams collide inside two huge detectors which allow scientists to study the details of the collision process. In another mode of operation, the proton beam is accelerated to 1 TeV, extracted, and collided with fixed targets. In all of these processes scientists hope to gain a better understanding of the structure of the proton and neutron and how they interact with one another. They also search for new particles, never before detected.

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[23] "CEBAF User's Handbook," published by the User Liaison Office, Continuous Electron Beam Accelerator Facility, Newport News, Virginia, 1991.

[24] "Focus on Fermilab," published by The Public Information Office, Fermi National Accelerator Laboratory, Batavia, Illinois, 1991.

VII. Brookhaven National Laboratory (BNL)[25]

(Located in Upton, Long Island, New York)

As many as 2000 faculty hold appointments at BNL in any given year. Their periods of stay vary from several weeks to a full year, and many receive salary support from BNL.

Brookhaven's four big machines form the heart of their research programs. They are the following:

1. High Flux Beam Reactor (HFBR)

Each year, about 200 international researchers join BNL scientists in using the HFBR for neutron-based research in numerous fields, including biology, chemistry, physics, and metallurgy. Unfortunately, since 1989, HFBR operations have been suspended for safety reviews.

2. Scanning Transmission Electron Microscope (Biological Research)

3. National Synchrotron Light Source (NSLS)

This device accelerates electrons in a curved path to produce a broad spectrum of radiation ranging from infrared to ultraviolet light and X-rays. It is used for basic and applied research in a wide variety of disciplines: physics, chemistry, biology, materials

[25] "Brookhaven Highlights," published by the Public Affairs Office, Brookhaven National Laboratory, Upton, Long Island, New York, 1990.

science and various technologies. In 1990 alone, 1,829 researchers from 292 institutions used the facility.

4. Alternating Gradient Synchrotron (AGS)

This machine accelerates protons to 33 GeV, polarized protons to 24 GeV, and heavy ions up to 14.5 GeV per nucleon for experiments located along a total of 17 beamlines. It also provides the most intense beams of kaons in the world for rare kaon decay research.

In recent experiments, scientists have been smashing heavy-ion oxygen and silicon beams against targets of aluminum, carbon, copper, silver, and gold to detect a quark-gluon plasma, a sort of soup made out of the constituents of the proton and neutron. In 1990, there were 640 researchers from 92 institutions performing experiments at the AGS.

In 1997, the AGS will serve as the Booster for the Relativistic Heavy Ion Collider (RHIC). In RHIC, heavy ions will collide at combined energies of 200 GeV per nucleon for gold and 250 GeV for protons, opening the door for a look at the conditions that existed in the universe just moments after the big bang.

VIII. Lawrence Livermore National Laboratory (LLNL)[26]

(Located in Livermore, California, near San Francisco)

Lawrence Livermore National Laboratory employs over 8,000 people and has an annual budget of over $1 billion. Some of its research programs include the following:

1. Laser Inertial Confinement Fusion (ICF) Program

This research effort offers the possibility of a cost-effective, safe, clean, and unlimited power source for the future. The laser system used in this program is called Nova, the world's largest. Its 10 arms produce bursts of laser light that together deliver more than 100 trillion watts of power in a billionth of a second to a pellet containing deuterium and tritium. This sudden implosion causes the deuterium and tritium nuclei to fuse, thereby hopefully releasing more energy than was incident on the pellet to make it implode. There is a Nova upgrade plan in the works to demonstrate fuel ignition and a modest gain of 2-10 by the end of the decade.

2. Magnetic Fusion Energy Program

Recent work in magnetic fusion has concentrated on the tokamak magnetic-mirror approach to confinement. Also, there is a collaboration with fusion researchers in Japan, Russia, and the European community to design a major tokamak machine called the

[26] "*Working at* Lawrence Livermore National Laboratory: Science and Engineering on the Grand Scale," published by Lawrence Livermore National Laboratory, Livermore, California, 1990; and "Energy & Technology Review: The State of the Laboratory," also published by LLNL, 1991.

International Thermonuclear Experimental Reactor (ITER).

3. Fossil Energy Research

LLNL is a leader in fossil energy research, with efforts in

a. Studying the production of oil from shale

b. Developing new catalysts and processes to convert methane and coal to liquid fuels

c. Contributing fundamental knowledge to understanding the formation of petroleum.

One-third of all the physicists who work at LLNL pursue research within the scientific disciplines of condensed matter, atomic, nuclear, plasma, atmospheric, and astrophysics.

IX. Los Alamos National Laboratory[27]

(Located in Los Alamos, New Mexico)

Los Alamos National Laboratory has 7600 regular full-time employees and an annual budget of over $1 billion. Research areas at the laboratory include energy, nuclear safeguards and security, biomedical science, computational science, environmental protection and cleanup, materials science, and other basic sciences. More specific endeavors include the following:

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[27] "Los Alamos National Laboratory: A National Resource," produced by the Information Services Division, Los Alamos National Laboratory, July, 1990.

1. Laser Inertial Confinement Fusion Program

This program is concentrating on the Aurora laser system, a short-pulse, high power krypton fluoride laser that is the world's first prototype for demonstrating the complete technology of large-scale ultraviolet laser systems. Aurora has recently achieved an important milestone by producing powers of 100 trillion watts per square centimeter. Scientists are using Aurora to provide the initiating conditions to produce controlled fusion in the laboratory. The ultimate objective is to determine if inertial fusion can be used to produce economical electric power on a commercial scale.

2. Magnetic Confinement for Generating Fusion Energy

3. Free Electron Laser Program

By using a free-electron laser (FEL) to generate ultraviolet light with very short wavelengths and by using highly reflective mirrors, Los Alamos scientists expect to develop an efficient way to produce semiconductor chips that will be 10-20 times more effective than those currently available.

4. Superconductivity

Los Alamos, Oak Ridge, and Argonne Laboratories were named superconductivity centers by DOE. At Los Alamos, they are focussing on synthesizing new materials to be used as superconductors.

5. Parallel Processing

Los Alamos, Argonne, Rice University, and Caltech form a consortium to establish a science and technology center for research in parallel computing.

6. Center for Nonlinear Studies

Laboratory mathematicians and scientists work together on a host of interdisciplinary problems and seek analytic solutions to nonlinear systems.

7. Clinton P. Anderson Meson Physics Facility (LAMPF)

LAMPF is the world's largest and most sophisticated medium-energy proton accelerator. About 800 users from the U.S. and abroad use the facility to study nuclear and elementary particle physics, atomic physics, nuclear chemistry, radiobiology, and condensed matter physics.

X. Summary

We started this working meeting of the Bouchet Council with Professor Allotey giving a description of the research facilities at selected universities and other sites throughout Africa. African Americans should certainly avail themselves of the opportunities to visit these research centers and develop longstanding collaborations. In this final session of the working meeting, we have tried to summarize both the global research picture in the United States and some specific "hot" areas of scientific and technological endeavors. The potential for African/African-American collaborations in these fields is unlimited.

BUT IT IS UP TO US TO REALIZE THAT POTENTIAL!

Notes on the session "Research Opportunities in the United States"

Milton D. Slaughter
University of New Orleans

* Of private corporations, national laboratories, universities and colleges, the private corporations are not the best places for research, although there are exceptions like AT and T.
* There are both advantages and disadvantages in working at a national laboratory. Advantages include lots of people doing diverse types of research; high-powered scientists doing high-powered research. Also, "risky" research can be done. Disadvantages include lower salaries, lack of support for graduate students, mission oriented.
* There was much discussions regarding Sekazi's statement on lab salaries. It could be somewhat misleading to say unequivocally that lab salaries are lower than in universities.
* Mickens stated that there exists funds at the NIH for a variety of research in the physical and mathematical sciences. Examples of such areas are AID's research (mathematical models), mechanical properties of bone, biological oscillations, etc. This could be an important source of funds since African scientists (and students) tend to be strongly mathematics oriented.
* Comptuer software development is very promising. Perhaps this is an area where the Bouchet–ICTP should look.
* In principle, Bouchet–ICTP facilitates not just physics activities, but, all areas of science. No research area is taboo. It is just a historical "accident" that physicists initiated the Bouchet–ICTP efforts. As collaborations increase and broaden, natural broading of Bouchet–ICTP activities will occur.
* Sekazi and others mentioned a number of African scientists who are currently working in the West in advance research areas. For example, a professor from Ghana who participates in high-energy physics research at DESY (Hamburg, Germany). Joe Johnson

said: "African colleagues can be at the forefront of research to non–Africans." Robert Bragg stated that we must use the "rifle not the shot–gun" approach in choosing research activities, i.e., research projects must be selected carefully.

* Sekazi thinks that materials research will be very important for Africa in the future. Advanced photon sources and other related machines will come on line in the mid–1990's. This should allow for many possibilities for collaborations.
* A possible source of funding for Bouchet–ICTP activities is the targeted DOE HBCU money. The connection here would be through the HBCU's and their principal investigators.
* Bouchet–ICTP should become more heavily involved in facilitating African graduate students coming to U.S. universities for graduate studies.

On My Experience with the Edward A. Bouchet–ICTP Institute

Issa Ramadhani*
Department of Physics
Clark Atlanta University
Atlanta, Georgia 30314 U.S.A.

It was during my stay, in 1989–90, at the Institut de Mathematique et des Sciences Physiques (IMSP) of Porto–Novo, in Benin, that I learned for the first time about the existence of the Edward A. Bouchet–ICTP Institute. In August 1990, I attended its second International Conference in Ghana which was a great success. From IMSP, as nominee in the exchange program under the Bouchet–ICTP Institute, I made arrangements to travel to the USA which I found very beneficial. I express my gratitude to those who made it successful, particular to Professor Ronald E. Mickens and Clark Atlanta University (CAU) for hospitality, financial support and providing excellent working conditions. The efforts of CAU in both encouraging minority students and providing a Center for Excellence in Science and Technology is a good example for African universities.

The Bouchet–ICTP Institute gives an opportunity for many African scientists and engineers to break with their isolation and to update the current state of their research activities and educational systems.

The gap between developed and developing countries, particularly African countries, is too wide. The cause is essentially the science and technology gap. Until recently, many African countries placed their strongest emphasis on technology transfer to improve the development. But this policy has failed.

Through the French experience, we know that since De Gaule France has put great emphasis on boosting its scientific and technological performance. The government expenditures on science have steadily increased at rates that are surely above international averages. Today, "French" technology has a remarkable world wide recognition. In a similar fashion, the recent high level science and technology activities of Japan have made the Japanese miracle possible.

Consequently, the political and economical changes taking place in Africa have made science become a major priority. The Bouchet–ICTP Institute is a pragmatic and positive forum that addresses the needs that foster African development. My hope is that our cooperation will be strengthened and deepened in the future.

* Permanent address:
1) Institut de Mathematique et de Sciences Physiques
B.P. 613
Porto–Novo
BENIN

2) Université de Kinshasa
Departement de Mathematique
B. P. 190
Kinshasa 11
ZAIRE

LIST OF CONFERENCE PARTICIPANTS
(Current Mailing Addresses)

1. Francis K. Allotey
Department of Physics
University of Michigan
Ann Arbor, Michigan 48109

2. Kwame A. Boakye
AT and T Paradyne
8545 126th Ave. North
Largo, Florida 34649

3. Kwasi Bofah
Tuskegee Institute
614 Robert's Circle
Tuskegee, Alabama 36086

4. Kofi B. Bota
Vice President, Research and Development
Clark Atlanta University
Atlanta, Georgia 30314

5. Robert H. Bragg
University of California
Hearst Mining 370
Berkeley, California 94720

6. Charles Brown
(AT and T Bell Labs)
4426 Newcastle Circle
Lithonia, Georgia 30038

7. John S. Hurley
Hampton University
Center for Nonlinear Analysis
P. O. Box 6106
Hampton, Virginia 23668–0101

8. Shirley A. Jackson
Department of Physics and Astronomy
Rutgers University
Piscataway, New Jersey 08807

9. Anthony M. Johnson
AT and T Bell Laboratories
Rm 4D-321
101 Crawfords Corner Road
Holmdel, New Jersey 07733-3030

10. Charles H. McGruder, III
Physics Department
Fisk University
Nashville, Tennessee 37208-3051

11. Ronald E. Mickens
Department of Physics
Clark Atlanta University
Atlanta, Georgia 30314

12. Sekazi K. Mtingwa
North Carolina A and T University
Department of Physics
Greensboro, North Carolina 27411

13. Issa Ramadhani
Physics Department
Clark Atlanta University
Atlanta, Georgia 30314

14. Abdulalim A. Shabazz
Department of Mathematics
Clark Atlanta University
Atlanta, Georgia 30314

15. James C. Turner
Hampton University
Center for Nonlinear Analysis
Hampton, Virginia 23668

National Society of Black Physicists

Current Mailing Address:
c/o Irvin Heard, Jr.
Department of Physics
The City College, CUNY
Convent Avenue @ 138th St.
New York, New York 10031
Tele: (212) 650-6930

Officers for 1990 - 92:
President
Dr. Kennedy Reed
Lawrence Livermore Laboratory
President Elect
Dr. Sekazi Mtingwa
Argonne Laboratory

Administratice Executive Officer
Mr. Irvin Heard
The City College, CUNY
Technical Executive Officer
Prof. James Gates
University of Maryland
Treasurer
Prof. Lonzy Lewis
Jackson State University

March 19, 1992

Dr. Charles Brown
AT&T Bell Laboratories
2000 Northeast Expressway
Norcross, GA 30071

Dear Charles,

Regretfully, I will not be able to participate in the Working Meeting of the Bouchet Institute in Atlanta on March 28 and 29. As you know from our many discussions, there are some very important goals which are shared by the Bouchet Institute and the National Society of Black Physicists. I think that it is important for NSBP to be actively associated with the Bouchet Institute, and I would like for the Society to stay informed about and involved in the work of the Bouchet Institute. With this in mind, I have asked President-Elect Sekazi Mtingwa to represent NSBP in the Working Meeting and to report back to the Society. He has agreed to do this.

I also feel strong personal regrets about having to miss this meeting. There are discussions listed on the program that I would very much like to hear. Since the Bouchet meeting in Ghana I have been corresponding with several scientists and students on the African continent, and I have a strong interest in all of the issues on the meeting agenda. In addition to my discussions with Sekazi, I hope to talk with you and others after the meeting. I would like stay abreast of the activities of the Bouchet Institute and keep in touch with other people working on these issues.

Sincerely yours,

Kennedy Reed

Kennedy Reed, President
National Society of Black Physicists

cc: Dr. Ronald Mickens
Dr. F. K. A. Allotey